NUT GROWING

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A mile of trout stream where the deer come to drink and where experiments in nut growing are conducted.

NUT GROWING

BY

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New York

THE MACMILLAN COMPANY

1921

PRINTED IN THE UNITED STATES OF AMERICA

Set up and printed. Published October, 1921.

Press of
J. J. Little & Ives Company
New York, U. S. A.

PREFACE

Here is a book intended to serve as a general guide for leading the reader into a new field of agriculture. When the subject has captured the imagination of amateurs lust of the chase will then do the rest. Many hands will make light work of research and experiment. Tree nuts are the only ones described and not many kinds of these—just enough to cover the principles and main points of nut growing. It is necessary to omit notes on hundreds of varieties and species of nut bearing trees and shrubs. Tropical nut trees bearing crops of nuts for which there is a large established market are interesting to people of the tropics, but this book does not go so far toward the equator. Nut bearing annual plants, including water plants which furnish a basic food supply for many people in distant countries, belong to a large volume not yet written.

One of the objects in publishing these pages at this time is to present a certain simple new method of grafting as promptly as possible because the obstacle of difficult grafting has stood in the way of development of the subject. A clever youth guided by the instructions here given may to-day do better nut tree grafting or fruit tree grafting than could

have been done by any one excepting the most expert horticulturist two years ago. The simplest methods of propagation known to the author have been described, the idea being to show one way for doing things successfully.

The subject of nuts leaped into the firing line as a twentieth century movement along with development of the automobile, wireless telegraphy, and the aeroplane.

America has suddenly become aware of the food value of nuts and their relation to the shortage of labor question. A tree works while the farmer sleeps and his hired man goes to town. Men who know most about nuts are afraid to present their ideas in book form at this moment of rapidly changing knowledge of the subject. The Georgia pecan grower would not accept all of the California walnut grower's conclusions of to-day and neither one of them would feel comfortable with information coming from Pennsylvania chestnut growers. There is need right now for a little book that will press a button and turn the light on the essentials of the subject. The general farmer is asking for such a guide and so is the amateur garden lover. The professional nut grower says that he would like to look that sort of book over in order to check up some of the things that he has forgotten about.

In order to keep abreast of the times the reader who finds that he is developing a brotherly feeling toward the red squirrel will observe that he needs to have access to a good deal of reading material.

Literature on the subject of nuts and nut culture has now become so voluminous that no one excepting the student with library facilities at hand could fairly hope to know what is being done in this rapidly expanding new field of interest and activity. The amateur may do practical work with the aid of this small brochure but he should in addition subscribe to the *American Nut Journal,* published at Rochester, New York. Membership in the National Nut Growers' Association and the Northern Nut Growers' Association will allow him to come in contact with the experts and to receive copies of reports upon annual transactions of the associations.

In California, Georgia, and Pennsylvania the incomes of nut growers frequently rank with the larger incomes of men in the learned professions. Such was not the case previous to the year 1900 in this country, although in the Old World nut crops have furnished the chief income from large districts for centuries.

According to a Department of Commerce Report the total value of all nut importations into the United States for the year 1919 was $57,499,044. We might, as well as not, have produced the larger part of the various nuts going into this valuation. Walnut and pecan growers have made an excellent start. The everyday farmer and gardener will find a new interest, one that will help to keep the boys on the farm, when he adds nut culture to his older routine work.

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PART I

General Notes

GENERAL NOTES

Our next great meat supply stands all ready to be released whenever man chooses to dispose of the natural enemies of the reindeer, musk ox, and northern bison. Having applied his intelligence to the removal of natural checks to increase of these animals he may then complacently view the rapid expansion of new and beautiful fat herds over the boundless pasturage of circumpolar lichens and grasses.

An irresistible fish supply will come sliding out from the waters and over our tables when man wishes to unlock the floodgates and say go to the fish breeder and fish protector. The seas and rivers are now awaiting the call for them to do their part.

In this twentieth century of ours extensive studies have shown that nut trees of many kinds are capable of furnishing all of the proteins, oils, and vitamines belonging to the meat group of foods. This does not mean that we are to substitute nut cakes for lamb chops. It means only that practically limitless additions are to be made to that particular group of foods.

What is a food supply? In relation to man it signifies the kind of food that men of any one part of the world have become accustomed to eating.

Furthermore, it includes the idea of acquiring that sort of food in accordance with the way of living. An American Indian required several square miles of land in order to thrive by his way of living. He could not exist at the Chinaman's rate of three to the acre on land cultivated intensively. A Chinaman suddenly deposited upon an Indian's square mile would not know how to get his breakfast. All of this relates to the adult Indian and Chinaman and to what psychologists call his thought-habit. Adults ought to be quarantined largely because of their attitude toward economic questions in general. An Indian child or a Chinese child may easily be taught to live like the adults of each other or in some better way altogether. New thought-habit in relation to foods is now the order of the day because of rapidly increasing population. Thought-habit is desirable for daily working purposes until it reaches its limitations. Limitations are reached when any man imagines that the world is really faced by questions of shortage of food supply. Were wheat, corn, rice, and other grains to be suddenly stricken from the Earth, man might then live better than ever before. Nut crops with their large average yield per acre at less expenditure of labor would furnish more of the food essentials than are to be obtained from grain crops. Famine occurs in grain regions rather than in tree regions. Primitive man depended upon wild plants and animals for his food supply. In a second stage of development man has come to depend upon cultivated plants and domesticated ani-

mals. In a third stage he will depend upon crops which require less labor and cost in general, but this stage will presumably not be reached until he has fought many wars in the interest of his thought-habit grain crops. The wild turkey following a line of grains of corn through an opening beneath a log pen holds his proud head erect after disposing of the food that was in sight. Looking upward toward Heaven for ways of escape he sees no outlet from his predicament. His pen is already over-populated and he would favor restriction of the birth rate. The turkey might be out of the pen and in the midst of an abundance of delicious beechnuts and wild grapes in two minutes excepting for his thought-habit. As a highly intelligent bird he is too nearly human to attend to that matter.

The author asked Professor Knight Dunlap if psychologists had an explanation for the fact that men have so many resources for resisting the introduction of knowledge into themselves. Professor Dunlap answered as follows:

"I do not believe that there is any specific 'mechanism by means of which men resist the introduction of knowledge into themselves.' I think the resistance to introduction is just one phase of the general tendency of the mechanism to function in the ways established by instinct and habit. If you consider the organism as a machine, which has certain specific lines of action through heredity, which lines are developed and modified through experience (habit formation), we should expect to find that an

organism too easily modified would be illy adapted to survival in the world of varying influences playing upon it. A certain sturdiness, that is to say, a certain resistance to modification, seems essential for the whole range of processes controlled by the nervous system. Is not this, after all, the fundamental law of habit? On the other hand, an organism which is not susceptible of modification, that is, which cannot form new habits, is also inefficient. The organism which has just the proper balance between its tendency to function along the lines of habits already formed, and the tendency to modify these habits where necessary, is, of course, the most efficient."

Huxley said that, in comparison with the ravages of that terrible monster over-population, all other problems are effaced, insignificant. Some of us do not believe that any such monster is more real than is the hoop snake.

If the increase of population in any locality is accompanied by large improvements in the arts of providing, distributing, and making use of food the effects of over-crowding are not injurious to a race in so far as the food supply question may be involved. Nut trees which may be grown upon almost every habitable acre in the temperate or tropical world introduce a new, large improvement in the art of production. Distribution is facilitated by the fact that nuts are not perishable like meats and vegetables and we have plenty of time for gathering the crop and spreading it about over various markets. Improvement in ways for making use of nut

foods is coming from laboratories and kitchens so rapidly that we now employ nut products by the ton where they were used in small lots at the beginning of the century.

Malthus in 1798 published his famous essay on Principles of Population, before the days of steam transportation. He placed stress upon the idea that human beings if allowed to multiply without check would increase beyond the food supply. This assumption, if correct, would have to include the idea that man is to remain stupid. Up to the days of Malthus history had recorded checks to over-population by way of pestilence, war, and famine. By pestilence we now mean the microbe. Medical science with its new knowledge of the microbe has taken charge of the question of epidemics to such an extent that we have lost our feeling of helplessness in the matter. War, the second check described by Malthus, will be diminished when sociologists make as thorough a study of politicians as the doctor makes of microbes, and when a league of nations then made possible will exercise police control over the varieties of capitalists who are responsible for infecting diplomats harmfully. Famine, the third check, may be lessened in the natural course of educational advancement as rapidly as men are willing to be taught the principles and practice of effective agriculture.

The most important and persistent check to over-population was not understood in the day of Malthus. I refer to cultural limitation or what is known

to farmers as the "running out" of any given variety of cultivated plant or animal. Civilized man is a cultivated animal, and his varieties in nations run out. This particular fact allows us to look with equinimity upon the food supply question, knowing as we do that all men whom this earth is capable of producing may be well fed for all time, while one nation after another is running out.

The question of food supply will relate only to the way of living—something quite remediable when found to be unsatisfactory for any large group of people.

Dr. Oliver Wendell Holmes commenting upon the Malthusian doctrine spoke of the time when we would all be sitting in each other's laps because of the lack of room. He did not know about the apædion index to the decline of nations, or in simpler words, the dropping of the birth rate. Professor J. Russell Smith in the humor of Dr. Holmes has introduced the idea of his three-story garden for congested population areas. There are to be nut and fruit trees over the garden. The ground floor will be devoted to ordinary annual crops and in the cellar underneath the garden there is to be a bed of mushrooms. We need not become unduly uncomfortable concerning the question of over-population because the law of cultural limitation will attend to the matter thoroughly. Nations will come and go as they have come and gone in previous cultural periods.

The way of living of each nation determines not

only the degree of intimate need in the way of food supply but also the degree of help which any one nation can give toward establishing better economic equilibrium between countries of the world. Over-populated areas are crowded because of the way of living and not because ways for giving relief are unknown. Distribution of knowledge is quite as important as distribution of food products. We have experts enough in every field of human activity but man does not know how to use the experts which he has. A congested area is surrounded by land capable of being widely opened by experts in agriculture.

The New York Times for December 20, 1920, published the following note in a box column.

> BOSTON, Dec. 19.—The United States will have a population of 197,000,000 people, the maximum which its continental territory can sustain, about the year 2100, Professor Raymond Pearl of the Johns Hopkins School of Hygiene and Public Health estimated in a Lowell Institute lecture last night.
>
> To support such a population, he said, 260 trillion calories of food a year would be needed, and judging from the production of the last seven years, when the maximum population was reached, it would be necessary to import about half the calories necessary for sustenance.

One spring the author was undecided about the number of shrimps to be purchased from a dealer for the purpose of stocking his stream at Merri-

brooke with natural trout food. Taking into consideration the known breeding habits of *Gammarus pulex,* a part of the problem could be reduced to figures. It was found mathematically after the manner of population statisticians that at the end of three years or so the progeny from one thousand shrimps would fill the bed of the stream completely and oblige the water to run out upon the bank in order to get around them. Four thousand shrimps were ordered and the trout now have to be lively in order to get their share of unearned increment away from other fish and from the larvæ of helgramites, dragon flies and the ephemeridæ.

Population estimates which do not take into account the apædion* index in its relation to cultural limitations of man and of his domesticated animals will be as misleading for us as they presumably were for the sociologists of Rome, Greece and Egypt.

Biologists and chicken breeders have their own views concerning the fall of Rome.

Japan appears to be crowded because of agricultural thought-habit. Japanese chestnuts, heartnuts and pine nuts would furnish a better balanced food ration and at less cost than the customary food ration now belonging in the rice category. Physical strength of the people would be increased in the course of a single generation on a nut diet. North American nut trees and nut bearing annual plants would thrive in Japan, furnishing a luxurious range in qualities of food beside supporting a population

*Alpha privative. pædion.

many times that of Japan to-day. That little country might increase its national wealth quickly by exporting to other countries nut crops to the value of battleships. Politicians now take away the earnings of useful people and put the money into armamentarium for their gunmen of armies and navies.

Japanese scientists ranking among the highest in the world know very well how Japan might set an example for all civilization if battleship money were to be turned over to agricultural educational institutions. Thus would a proud people have justification for a pride based upon pragmatic results of application of keen intelligence to the food question. There is small likelihood of any one civilized country taking any such advanced position while human nature is abroad during our cultural period. One may at least speculate upon that sort of possibility for some of to-morrow's nations.

The naturalist may fairly assume that the imperialistic oligarchy of Japan will be more interested in quietly gaining control of India, China, Eastern Siberia, the Philippines and other strategic points in preparation for hurling Asia against the white man's countries. This political process appears to be well under way at the present time while the Anglo-Saxon is declining and is committing suicide in his profitless civil wars.

Asia might make another sort of revolution by showing that its land is not "occupied" and that limitless new kinds of food supply would take charge of the expansion question.

"Every nation can and ought to colonize for the sake of its own expansion and, all of the territory of Europe being occupied, we must attempt to get possession of colonies in foreign countries," said Nicolai.

Is all of the territory in Europe occupied? By no means. Occupation in this sense relates simply to methods of living up to the present time. The land cannot fairly be said to be occupied in Europe when wolves are still a pest in the forests of France and when almost every acre traversed by these wolves would produce hundreds of pounds of nut products for man and his domesticated animals every year.

It is said that a machinery victory is the only possible victory over the land in these days when there is increasing tendency for men to leave the land and go to the cities, but the tree is a machine. So is the annual plant a machine for that matter, but the tree is a machine that is working day and night with less attention required from man than the annual plant requires. The struggle for existence is basically a struggle for sustenance. All commercial life depends upon plants because plants alone are capable of extracting potential energy from the earth. The cause for war is fundamentally acquisition of property, but if property may be acquired through warfare upon nature it is more desirable than warfare by man upon man. The latter has often been called a business, but from my point of view it is a sport of rulers and one which is destructive in all of its

final phases. Sociologists tell us that the food supply question is basic in relation to warfare movements. People who feel that they have land enough to supply food enough do not wish to fight excepting when they are misled by their politicians; the latter belonging to the non-producing social element.

War is not brought about in civilized countries by the useful people. It is brought about by the politician and tariffist who cannot think internationally and whose mind represents a reversal to the primitive or clan type. Take away from that kind of politician his argument about food supply and he will find ever-increasing difficulty in persuading fathers and mothers to send their fine sons to play his ruthless game and to pay his bills.

Agricultural experts in our state colleges can make people feel that we have land enough to supply food enough. The question is one of distribution of knowledge among the people, a function of the state. Not only may abandoned farms be made more profitable to-morrow than they were when at their best yesterday, but many of the so-called waste lands may be made to produce more food than has been commonly produced by soil of first choice up to this date in our own history. Even the swamp lands hold out an attractive feature for the producer who finds joy in new fields calling for a wider range of his keen interest and knowledge. Doubtless there are some swamps and wet lands which may be drained to advantage but legislators must carefully avoid granting privileges carelessly in the matter.

In some of the older countries of the world incomes for large districts depend upon water plants, fish, and other products of wet lands artificially made for the purpose. In this country we have already caused irreparable damage by draining lands of the sort which peoples with greater experience are today engaged in constructing.

Government estimates of wet lands in the United States capable of being drained and made ready for tilling, place the figure at sixty millions of acres. Reclamation of this wet land would be little short of criminal in localities where the wet lands at lesser expense could be made ready for crops belonging to such lands and sometimes bringing in larger income than tilled land crops. We have already thrown away much of our own rich heritage in wet lands. What would people do for bread in countries in which bread is made from the water chestnut, if the American drainage idea were to strike these countries like a blight? The water chestnut is already acclimated in America as far north as the Merrimac River in New Hampshire. Hundreds of square miles of Oriental wet land are devoted to the raising of the lotus—a plant of which every part is eaten. We have not as yet made use of a nut which was employed by the Indians—the wankapin or water chinkapin—but the time is coming when we may regret the loss of lands upon which this food supply may be freely grown.

Fish breeders and crawfish breeders of northern

Europe often support their families from shallow, artificial ponds of ridiculously small dimensions.

How many tillable acres have we in America that can compare favorably as to income with Maryland musquash leaseholds with delicious musquash meat now selling at thirty cents per pound and skins at more than three dollars each? Some one will reply that the present market price for musquash meat and fur is a war price, but so is the present cost of beef and wheat. How many tillable acres bring returns like the shallow waters of terrapin breeders? Wild-fowl breeders are already entering their protests against reclamation projects. The very word "reclamation" is a joke when we have so many millions of acres of tillable land that is wasted or improperly employed and when two or three kinds of wet land products can be profitably raised at one time upon one wet acre—water nut crops already being standard food crops abroad.

Irrigation projects in some localities may be quite as untimely as drainage projects in this period of our own history. Irrigated land will wear out precisely like other land and we are simply postponing the day when first rate agriculture will prevail. First rate agriculture will consist in raising forty bushels of wheat to the acre upon eight-acre land as is done at Rothamsted in England. Crops grown upon irrigated or drained land belong to second-class agriculture and first-class engineering. The farmer who boasts of his great crops raised so easily is the

rooster that crows when a hen has laid an egg. The engineer laid the egg. The large immediate returns are the large immediate returns of a man who puts his hand into another man's pocket.

An unfortunate part of irrigation projects often lies in the fact that beautiful tracts of land are destroyed unnecessarily. So long as good land may be purchased at less than a dollar per acre in some parts of the south it is not yet time for us to carry drainage projects and irrigation projects into territory where the result will simply extend second-rate farming and first-rate engineering.

Individuals and governments loan money for drainage and irrigation projects. If the same amount of money were to be devoted to the work of our agricultural colleges the world of to-morrow would be benefited. Individuals in particular and the present generation in general profit by our wasteful promotion of second-class agriculture. In the words of the poet they ask, "What has posterity done for me that I should do anything for posterity?" They are to shift the cost of engineering plants to a later generation when the time comes for plants of farmers to need more fertilizer. On the whole, to-morrow's population is to be the loser from such drainage and irrigation projects of to-day as are untimely.

According to the 1914 report from our Department of Agriculture forty per cent of the land in the United States is non-tillable. Aside from the non-tillable land which consists of swamps in which

food might be raised profitably a very large percentage of the entire acreage on higher ground already carries tree or bush crops for which we may substitute food-bearing nut trees and shrubs. There is but a small percentage of this untillable land excepting that on bleak, barren mountain tops which cannot be made to carry food crops equal in value to those of the sixty per cent of tillable land of the United States. For example, nearly one-half of the land in Connecticut is considered to be non-tillable land. To my personal knowledge there is little of such land in that State which cannot be made to raise nut crops more valuable than most of the crops which are now raised upon the tillable land in the State. Only twenty-seven per cent of the tillable land in the United States is actually under cultivation, but if we follow the same methods of plant and stock raising in the future it will not be long before one hundred per cent is occupied. As a matter of fact, intensive cultivation of twenty per cent of the tillable land now occupied could be made to produce so much more than it does under present methods that we need have very little anxiety about the need for bringing one more acre of tillable land under cultivation with ordinary crops for some time to come.

One may ride for mile after mile upon the railroads through old settled parts of New York and New England and see on every side worn out sheep pastures supporting many woodchucks and grasshoppers, that could be made to yield good income. On

some of the western prairies one may look clear to the horizon and see only French weed, thistles, and wild mustard where once was corn and waving grain —the land now practically abandoned because farmers would not change their crops or do subsoil plowing. While this state of things remains it is all wrong to open up more unimproved land. We are simply increasing competition between men engaged in the lower planes of agriculture.

Is there a deserted hillside sheep pasture in the east or a mustard prairie in the middle west that cannot be made to grow one hundred dollars worth of nuts per acre annually? Probably not.

The attempt to raise corn and other grain crops on the Appalachian hillsides has been extremely destructive because of soil erosion following in localities in which nut tree crops would have given much larger incomes from the same land with the avoidance of erosion and exhaustion of the soil. The deserted farmlands of the eastern states would not be deserted but would be yielding large permanent incomes if tree crops of grafted acorns, hickories, beeches, hazels, and black walnuts had been planted where now the ground is occupied by chipmunks and sumac.

When bird shooting in North Carolina and obliged to jump over deep erosion gullies in the fields all day long, I said to a farmer that his land was running away from him. He replied that he was well aware of the fact but did not know what to do about it. His fields yielded less than ten bushels of wheat to

the acre, and the tobacco crop in some years failed to return a profit. My suggestion was to put the best of his land into grafted hickories and black walnuts, and the poorest land into grafted seedless persimmons. One acre treated in this way would yield more income per year than he could get from several acres treated laboriously and with loss of soil in gullies. The trees and grass would hold his land and there would be no trouble from night riders.

Thousands of square miles of hilly land that are now being gullied as a result of raising meagre crops of annual plants may be put into tree crops and saved. Lands that are level or moderately rolling are the only ones in this country that we can afford to devote to crops of annual plants. The loss of land in hilly districts relates not only to the people of to-day but to the generations of to-morrow.

Professor F. K. Moulton in a paper read at the meeting of the American Association for the Advancement of Science in 1920 is quoted as saying that the intelligence of man to-day compared with what it will probably be in future years is in the same ratio as that of a toad when compared with our present development. He is doubtless right. We are toads in our management of land and we cannot hop over our gullies because there is no one in authority to oblige us to make larger incomes and to desist from running our soil down stream.

Professor J. Russell Smith in his book entitled "The World's Food Resources" states that "great is the contrast between these poor uncomfortable,

whisky-cursed, law-breaking mountaineers of Appalachia and the comfortable, prosperous inhabitants of similar but less favored slopes in Corsica. I have traversed miles of mountain slope in Corsica having the angle of a house roof. The slope was steep but a good road wound in and out along its face. At intervals we passed through villages of substantial stone houses with well built churches, well stocked stores, and often comfortable inns."

This relates to a country much like our southern Appalachian region but devoted almost wholly to chestnut trees. One may travel for many miles in Corsica finding hardly a break in the continuous orchards of grafted chestnut trees supporting a dense population in comfort. When the blight from China strikes these trees the people skilled in chestnut growing may import blight-resistant hybrids developed in America and in that way avoid permanent loss.

Our agriculture in North America represents a tradition from level lands and dating back to the days of savages when men had to devote most all of their time to killing each other along with other large and small game while women raised small annual crops of grains. In those days the kaleidoscopic shifting of tribes was inimical to tree culture but fitted better into the cultivation of annual plants. The effect of tradition is so strong that in the Chinese Empire men crowd certain areas and develop intensive agriculture suitable to the crowd life. On the other hand, not far away from some of the Chinese cities tigers and leopards menace the herdsman's

property and wild apes find easy living without touching a hoe. China is not densely populated where tigers live. The crowding is a social matter and will not be real until wild apes have to take to the hoe. Tradition in agriculture has meant wicked waste of opportunity in America and it is now time for us to awaken to the situation and teach the old world what may be done with our new agriculture based upon nut tree crops.

The reasons for development of a new world-wide agriculture relate to the difficulty which the farmer finds in meeting modern conditions. He has passed what is called the pivotal point and is now face to face with the law of diminishing returns. This is but a repetition of history belonging to established method which is practical until changing conditions call for changing method.

While botanists sat upon their stools laboriously turning over petals in a search for new classifications, troubling each other without making great advance, medicine opened up the great new field of bacteriology and successfully conducted a whole revolution which might otherwise have gone to the credit of botany. In much the same way agricultural development of standard food materials has meant technical study of such standard materials rather than emergence into brand-new fields of supply.

A great development of cereals took place as a result of experimental work during the nineteenth century, but the twentieth century is to go on record

for the sudden emergence of nut culture. There are several reasons for this unexpected event.

1. Shortage of farm labor due to decreasing birth rate and increase of movement toward urban life came acutely to our attention in the early years of 1900.

2. Nut trees produce more of the food essentials in proteins, oils, and starches per acre than are furnished by ordinary field crops.

3. Nut crops require less labor and fewer hands for cultivation or for harvesting the crop. The trees may live and bear for more than a century, sometimes without apparent reduction of the fertility of the soil in which they grow. Difficulties which formerly stood in the way of successful propagation of nut trees have been done away with to such an extent that almost any boy or girl may do grafting work of the sort which defeated expert horticulturists two or three years ago.

Nut cultivation belongs to what has been called permanent agriculture. The meaning of the expression is clear. Transitory agriculture might be the opposite term as applied to rotation of annual plants. A tree does not exhaust the soil as a rule, while transitory agriculture regularly exhausts the soil unless fertilizers and methods of cultivation are employed with a higher degree of intelligence than is commonly in evidence. The profitable employment of fertilizers in crop rotation demands knowledge of such high order that comparatively few farmers are prepared to avail themselves of what is

known on the subject. Permanent agriculture, on the other hand, will allow a very much larger number of people to furnish food supply with a comparatively small equipment of information.

Professor Hobson of the Department of Economics of Columbia University has prepared statistics showing that the percentage of people on farms in the United States was 87.1% in 1870, 44.4% in 1880, 32.9% in 1910, and the proportion of farmers to town dwellers constantly growing less.

The United States Department of Agriculture studied eight thousand seven hundred and twelve farms in twenty-eight representative districts and found that the farmer averaged only five hundred dollars per year for his own long hours of work and for his management and responsibility. A path cleaner in Central Park, New York, is at present paid one hundred and sixty dollars per month for short hours of work and little responsibility beyond that of voting right.

When the question of food value of nuts is taken up it must be divided into two parts. Nuts for the feeding of domestic animals and nuts for human food. In this country and in other countries there are locations in which nut forage is very important for fowls, cattle, and hogs. This is the case where beechnuts, chestnuts and acorns occur in vast quantities as natural wild products. The time is no doubt near at hand when we shall cultivate nuts of the acorn group in particular in very large quantities, not only as forage food for live stock, but to be

gathered and stored for the purpose of forming part of the ration of domestic animals. This particular part of the subject will belong to studies further along in our history.

At the present moment the subject of nuts for human food is the one undergoing most active development. Many important reports on this part of the subject are coming from the public and private laboratories and the literature of this feature of the nut question has become voluminous. The notes following on the food value of nuts have been taken largely from the writings of Dr. J. H. Kellogg, who has given more attention to the subject in a practical way and for a longer time than any other authority with whose work I am familiar.

Nuts furnish starches, fats, and proteins, the three essential food elements. Different nuts furnish these essentials in varying proportions. Thus, almonds contain 21% protein, 54.9% fats, 17.5% starches, and 22% ash. Fresh chestnuts contain only 6% protein, 5.4% fats, but 42.1% starch and 1.8% ash. Peanuts contain 30.5% protein, 49.2% fats, 16.2% starch, 2.5% ash. These three kinds of nuts represent the characteristic varieties in the kinds of food material furnished by each one of the kinds.

An acre of land devoted to wheat may produce nearly ten times as much protein as the same acre devoted to pasturage for beef cattle. An acre of land devoted to nuts may be made to produce a still larger amount of food protein than is to be obtained from this wheat which, in turn, had excelled the

beef acre. The concentrated food in a nut has been stored up by the plant for the purpose of giving its progeny a strong boost upward toward success in the world, and for that reason each nut represents a prize package of the most concentrated food materials with very little of the waste belonging to the framework and structure of other vegetable products. The average number of food units per pound furnished by the more common varieties of nuts is three thousand two hundred and thirty-one calories while the average of the same number of varieties of cereals is sixteen hundred and fifty-four calories. The average food value of the best vegetables is only three hundred calories per pound and of fresh fruits two hundred and seventy-eight calories. The average value of the six principal flesh foods is eight hundred and ten calories per pound or one-fourth that of the nuts.

Although we are prone to speak of protein as a unit food substance, proteins from different food products vary largely in character. Nuts furnish proteins of such fine quality that they supply the elements necessary to render more complete the proteins of cereals and other vegetable foods. They are free from such waste products as uric acid, urea, and carnine which go with meats. Further than that they are nearly aseptic and free from bacteria of putrefaction at the time when they are eaten.

From an economic standpoint the raising of nuts possesses an advantage over the raising of meat. One hundred pounds of food fed into a steer pro-

duce less than three pounds of food in the form of flesh. We must feed the steer thirty-three pounds of corn in order to get back one pound in the form of steak. Milk and eggs furnish much the same protein as that furnished by meat, but milk and eggs are rapidly increasing in price. Every pound of food in the form of milk requires feeding a cow five pounds of food. For every pound of food in the form of eggs we must supply nearly twenty pounds of food. At the present time the prices of nuts are also high, but that is because the demand has not been met by the supply. Looking to the future we may state that the possibilities of raising food more cheaply by way of nuts are greater than the possibilities of raising food more cheaply by way of milk and eggs. In this connection it is interesting to note that one pound of walnut meats equals in food value five pounds of eggs, nine and a half pounds of milk, or four pounds of beef loin. Each acre of walnut trees in good bearing will produce every year food approximating twenty-five hundred pounds of beef, thirty-five hundred quarts of milk or one and a half tons of mutton.

The increase in the popularity of the nut foods will incidentally add a health factor not to be despised. Almost all of us like hot roast duck stuffed with sausage and chestnuts and with plenty of bacon gravy. We enjoy a delicious thick porterhouse steak, quickly browned on the outside with its fat temptingly burned a bit and red juice trickling out when the steak is cut. Because these things are so

good there is always a tendency for us to eat more of the meats than we can dispose of in our subsequent chemistry, and in consequence there is a great deal of illness, aside from the common rheumatism and gout, due to decomposition of the undigested portions of meat products. Some of us perhaps would prefer to die young rather than give up any of the good things in the way of meats. My personal sympathies lean somewhat in that direction, but if one is to employ meats extensively in his dietary, and do it safely, he really requires a great deal of physical exercise. The tendency at the present time is toward decrease in the degree of exercise. In all probability the expanding movement of nut foods will not displace meat foods very rapidly, but we may look for normal increase in ways for making nut foods so delicious that pleasure will accompany the gradual change from beefsteak to nut and soy steak. We may remember that in many parts of the world a vegetarian diet including nuts is an established fact. Whole races of men comprising millions live their lives without meats of any sort—the Brahmins of India, the Buddhists of China, and many of the Japanese, for example. Some of the sturdiest of the Scotch Highlanders have rarely ever tasted meat; sixteen children in the family sometimes.

An article on the Nutritive Properties of Nuts by Professor F. A. Cajori in the *Journal of Biological Chemistry* for September 20, 1920, states in the summary that:

"Satisfactory growth was observed in young rats on diets in which the almond, English walnut, filbert, and pine nut, respectively, furnished the essential source of protein in the ration.

"Normal growth can be secured when rats are fed upon otherwise adequate diets containing the almond, English walnut, black walnut, Brazil nut, chestnut, or pecan as the sole source of water-soluble vitamine. Animals which have declined on a diet devoid of water-soluble vitamine promptly recover when the almond, English walnut, filbert, hickory, pine nut, chestnut, or pecan is introduced in the diet. These observations indicate that nuts are sources of abundant quantities of water-soluble vitamine.

"The proteins of the almond, English walnut, pine nut or filbert furnish the necessary nitrogenous complexes for the elaboration of milk in rats."

The practical question in relation to nuts includes the idea that they contain not only the elements required for human food supply, proteins, oils, starches, but also the vitamines. Vitamines have not as yet been described chemically, but they are the factor which gives zest to the eating of food, and constitute a vital factor in our body chemistry. The measurable calories of nuts allow us to place the different kinds in the ration where they belong.

I remarked to a guest at the farmhouse who was eating some crisp red watermelon fresh from the garden and ice-box, that it did not contain many calories. This young miss replied that she did not want calories, that all she wanted was watermelon.

There is nothing to prevent us from having watermelon in the food supply any more than we are prevented from having some nice jingling dimes in the pocket along with a large roll of ten dollar bills. Both are handy to have in the house.

Aside from all such unpoetic questions as those of food supply, interest in trees belongs to a larger order than interest in potatoes, oats, and hay. There is more inspiration in a tree than in an annual plant because the tree seems to be a standing object lesson of highly organized forces, more stable and permanent than those of an annual plant. The larger love which men seem to have instinctively for trees will elevate standards of agriculturists who deal with them. The horse rancher is said to be of better average character than the sheep rancher, the difference being due to the difference in the characters of their separate wards. The hard continuous labor that goes with general farming and the social poverty as a logical consequence drives more and more young men from the farm today. Tree problems while giving free scope and range to the highest degree of science and knowledge which can be brought to bear do not include necessarily such an absorption of time that time limitation is placed upon travel, self-culture and the higher social needs. Trees once established still need attention to be sure, and the better the attention, the better the tree. They do not include the idea of getting farm income by sitting on a three-legged stool in a cold barn at five o'clock in the morning, with flickering lantern light and milk-

ing a heifer which will not give down until a log chain is laid across the small of her back.

Down in Louisiana they tell of an old colored man who barely managed to support his family with hard work in cotton and corn although he worked long hours and faithfully. Now that he is old and crippled with rheumatism, no longer able to raise cotton on his few acres, six pecan trees which he set out bring him a larger income than he had at the time when he could work at his best. This lesson may be carried to New England where grafted nut trees of many kinds will bring good income to the modern farmer.

The Big Four species of tree nuts for expansive development in the United States during the present century will probably be the pecan for the south, the shagbark for the northeast, the black walnut for the central west, and the Persian walnut for the Pacific coast. There will perhaps be controversy before long as to whether the pecan or the black walnut is to be our national tree. The pecan has the best running start but the black walnut has a larger range. All of these four species will overlap to some extent in all four localities and great progress will be made with almonds, hazels, chestnuts, and pine nuts. Among the annual plant nut crops the peanut will be grown largely on dry land and the water chestnut and the water chinkapin in wet acres now occupied by worthless reeds and water hyacinths. We may fairly predict that the Big Four group of nut

trees will overshadow all other nut tree production by the end of the century. At the present time the almond has forged ahead very rapidly. According to the United States Bureau of Crop Estimates report on the productive value for 1919 the value of almonds raised in this country was three millions of dollars, walnuts fifteen millions, and pecans nine millions three hundred ninety thousand. The almond, however, requires more attention than other nut trees and so far as we may now judge will have a more restricted area finally on this account.

Very valuable nut trees like valuable fruit trees up to the present time have been for the most part accidental discoveries. Our best trees in the future will presumably come from tree breeders, a large number of whom have been busily at work during the last decade with their numbers steadily increasing. There remain about the country, however, many notable wild nut trees, known to people in the vicinity. An organization like that of the Boy Scouts might render invaluable service to the country if one of its autumn duties was to consist in finding valuable nut trees and reporting upon them.

Nuts of the horse chestnut group, borne in heavy crops annually and with a large starch content, will undoubtedly become a valuable source of food supply when some chemist has found a way for extracting the disagreeable bitter element inexpensively. The American Indian prepares buckeye nuts of the horse chestnut group by pounding them up in

coarse bags and washing the bags with their contents in running water. The washed residue is then dried and made into cakes.

Cakes made from sweet acorns are already an important food in some parts of the Pacific coast region and we shall doubtless devise means for making palatable food from astringent and bitter kinds of acorns later. Tropical nuts of kinds not referred to in these pages will be raised more and more in the southern parts of Florida and of Texas.

A boy once asked me why it was that fruit farmers were more prosperous than other farmers. One who is familiar with the cattle, corn, cotton, and wheat farmers may deny the boy's premises, yet his observation made in western New York carried meaning. Trees are grown with less labor than is required for annual crops, they are cared for with ease, and fewer hands are needed for the work. The fruit farmer whose fruit ripens at a definite time in the year has an abundance of time for travel, attending society meetings, and for obtaining an enlarged view and outlook upon life which does not belong to one who is closely engaged with the time-consuming details of regular ordinary varied farm work. Nut trees are fruit trees. They represent kinds of fruit which do not require to be gathered in feverish haste for the market.

In the nut trees we combine the Greek ideal of utility with beauty, because nut trees are quite as beautiful as other trees. The reason why our parks, highways, and private grounds are not graced with

nut trees instead of mere bunches of leaves (to which we accord freely enough an estimate of beauty) is that people have not stopped to think about it as yet. If people in this century were to think of everything all at once the people of two thousand years from now would have nothing to do excepting to mope around and devote themselves to ancestor worship.

Along with development of nut industry at the beginning of the century came a need for expression on the part of men who were doing new work. Societies were formed and publications were planned for the purpose of recording and disseminating knowledge of the subject. The first journal devoted wholly to the subject of nuts was published at Poulan, Georgia, in 1902, under the editorial management of Dr. C. F. Wilson, although the *Fruit and Nut Journal* had been previously published at Petersburg, Virginia, with H. H. Hume and W. N. Roper as editors. The *Nut Grower* has given particular attention to the pecan and has been a potent factor in the establishment of that great industry in the south. In 1914, as a result of the suggestion of a pioneer in nut subjects, Dr. W. C. Deming, of Wilton, Connecticut, and a conference at Washington between Mr. R. T. Olcott, of Rochester, New York, editor of the *American Fruits Magazine,* President T. P. Littlepage, of the Northern Nut Growers' Association, Messrs. C. A. Reed, E. R. Lake, and C. P. Close, of the U. S. Department of Agriculture, the production of a national magazine for the develop-

ment of the nut industry was set on foot. It was believed by these men that such an undertaking would not in any way interfere with a publication like *The Nut Grower* covering a particular section but would supply needed information over a wider area. Shortly after that the *American Nut Journal* as a monthly publication appeared.

The first nut book in this country was published by the Orange Judd Company in 1896 under the authorship of Mr. Andrew S. Fuller. This little book while out of date in some respects is nevertheless brimful of valuable information. In the same year a volume entitled *Nut Culture* was published by the Division of Pomology of the United States Department of Agriculture. This latter publication, while out of print now, may be found for the purpose of reference in many agricultural libraries. The volume contains a large amount of material of such value that the student of the subject will need to have it on his reference list and he may be enabled to pick up a copy by leaving an order with a dealer in old books who keeps lists of books wanted. This is not such a hopeless resource as might be imagined as I have secured practically every old book for which I have ever placed an order within the course of a year or two. Professor H. H. Hume, of Glen Saint Mary, Florida, has more recently published a small book on the subject of the pecan which incidentally includes a great deal of material of general interest to growers of nuts of all sorts.

During the year 1901 Dr. C. F. Wilson, now of Waycross, Georgia, in correspondence with Mr. G. M. Bacon, of Albany, Georgia, suggested the formation of an association of men interested in nut culture. Mr. Bacon adopted this suggestion and a meeting at Albany, Georgia, in 1901, was the result of invitations which Dr. Wilson and Mr. Bacon had sent out. This meeting was held at the office of Mr. R. H. Warren, with Mr. Robert J. Bacon, of Baconton, as chairman, and Dr. Wilson, who had outlined the plans, as secretary. The name Southern Nut Growers' Association was adopted. Mr. G. M. Bacon was elected president. Dr. Wilson, secretary, and Mr. J. M. Tuft, treasurer. Mr. Herbert C. White joined the movement early in 1902, formed one of a committee that drafted a constitution and suggested that the name National Nut Growers' Association be adopted. In 1902 publication of the *Nut Grower* began as the official organ of the Association.

The Western Walnut Association was instituted by Mr. J. C. Cooper at a meeting of the Yamhill County Pomona Grange, July 24th, 1915, with about twenty growers present. Plan for organization was drawn up by a committee consisting of Mr. J. C. Cooper, Mr. M. McDonald, and Mr. T. A. Harper. *The Walnut Book,* periodically published by the secretary of the Association, Mr. H. V. Meade, of Orenco, Oregon, is the organ of the Association.

The Northern Nut Growers' Association was or-

ganized on November 17th, 1910, by the late Professor John Craig, of Cornell University; T. P. Littlepage, Esq., of Washington, D. C.; Dr. William C. Deming, of Wilton, Connecticut; the Author, and others present at the 1910 meeting which was held at the Botanical Museum, Bronx Park, New York, on the invitation of Dr. N. L. Britton. Dr. Britton called the meeting to order and stated its purpose. The objects of the Northern Nut Growers' Association had no direct relation to the commercial interests of the subject. Its ideals related more particularly to the botanic values of the question. Subjects like those of discovery and propagation of valuable nut trees with all the ramifications of the latter subject engaged the attention of the members. Public education and the interesting of colleges and schools in the new problems relating to nut culture formed a part of the work as planned. One of the very serious duties of the Northern Nut Growers' Association consisted in stating the terms of nut growing scientifically and in correcting errors, many of them widespread, which were being disseminated by nurserymen who had been too busily engaged in problems of distribution to give the right sort of attention to the fundamental facts. The National Nut Growers' Association, the Western Walnut Association, and the California Walnut Growers' Association have rendered particularly good service in developing the commercial features associated with nut growing and splicing of loose ends of business

method which entangle and hamper the progress of any developing industry.

A National Pecan Growers' Exchange is being organized at the present time in Georgia. This will be in the interest of development of the market and because men who are responsible to the Exchange will soon become known as such in the market and disappointments which come to the consumer from buying nuts of inferior quality and ungraded nuts will be done away with. The coöperative method of marketing as adopted by the California Walnut Growers' Association will probably be carried to different parts of the country and associations of responsible men will take charge of the subject.

The best results in nut growing will come from localities which are given over to large acreage of nut growers associated in such a way that they may benefit by the knowledge and experience of each other and act in a coöperative way in relation to the market. Such has been the experience in relation to the walnuts, hazels, and almonds of the Pacific coast and the advantages of the system are being carried to the cultivated pecan regions of the south. There is a tendency for individual nut growers to market their products independently. This involves unnecessary expense in distribution of varieties which might injure the market in the long run. Furthermore, nut growers' exchanges by setting the stamp of approval upon varieties which become standard from time to time will prevent irresponsible nursery-

men from advertising widely nut trees which are to go to wrong localities and which may be seedling trees or trees which will bring disappointment after several years of waiting for them to come into bearing.

Recently our United States Department of Agriculture at Washington has become actively interested in nut questions. Dr. David Fairchild, Agricultural Explorer, has added a number of new species from foreign lands. Mr. W. A. Taylor, Chief of the Department of Pomology, is now directing nut work in a large and progressive way. Requests for information on the subject of nuts should be made to Mr. Taylor. Mr. C. A. Reed, Nut Culturist, travels about over various parts of the country obtaining information which covers the whole field of American interest in the subject.

Along with increased interest in the raising of nut trees has come the psychology of the nurseryman expressed in various ways. Honest nurserymen seriously interested in promoting a new industry have carefully avoided making mistakes and have recorded their mistakes in such a way that they are at the disposal of all inquirers among their customers. Other nurserymen, equally honest perhaps, but busy with many other kinds of trees, have added nut trees to their lists and have frequently given a great deal of misleading information in regard to this special department. Many have sold seedling trees, sometimes by the name of a variety, because they were not aware of the fact that nuts did not

come true to varietal type from seed. Each tree would be of a different variety. A discouraging number of years are sometimes required for seedling nut trees to come into bearing and some of the seedlings hardly bear at all at any age. The third group of nurserymen, the careless group, taking advantage of enthusiastic interest in a new subject, have capitalized enthusiasm, sending forth their literature broadcast with misleading advertisements. Unfortunately the careless ones seem to be the ones with most money to spend for advertising purposes. A part of the work of the nut growers' associations has consisted in excluding the advertising material of careless nurserymen from the advertising pages of responsible publications.

All buyers of nut trees must be warned. Careful inquiry must be made before investing in nut trees, otherwise the entire subject will receive a serious setback from the wave of indignation from disappointed customers. So long as perfectly reliable dealers are to be found, buyers are urged to find these dealers by methods that they would employ when arranging for a financial investment of any other sort.

The Northern Nut Growers' Association invited all nurserymen dealing in nut trees to send their catalogues to the secretary for the purpose of having unintentional mistakes corrected. A number of them responded. Others have continued with misleading circular material.

PART II

PROPAGATION

NUT GROWING

CHAPTER I

SEEDS—SOILS—TRANSPLANTING

How is the amateur nut orchardist to go at his work? We may divide the answer into several parts. First there is the matter of land. What sort of land? The sort upon which hardwood trees are already growing or have grown. This offers the safest key to the situation although land which grows plants in general is pretty sure to carry nut trees when experimentation finally shows which ones are adaptable to the locality. Let us begin with any hardwood land and choose by preference nut trees which are closely allied to species already thriving in the neighborhood. This is better than attempting to transport nursery catalogue favorites from a distant climate.

What about making the start? Nuts may be planted for the purpose of giving us grafting stocks later. Larger trees on the ground may be top-worked with scions obtained from the nurseryman, from choice local trees, or from correspondents in exchange. This matter of hunting up correspondents

at a distance introduces a delightful feature of new work. One will find little islands of friendship among men in far away states and countries. The exchange of seeds, scions and ideas among enthusiasts of similar tastes adds the human social touch in a way that is most enjoyable.

A full orchard setting of grafted trees may be purchased from the nurseryman if expense is a minor question. One or all of these ways will suffice for the launching of the project.

The growing of nut trees from cuttings may be developed later but as yet has received little attention. I have succeeded in starting hazels and the alder leaf chestnut from branch cuttings and the shagbark hickory from root cutitngs, but not to a practical extent. Experimentation under hot house conditions should be carried out with cuttings from all of our nut trees. In *American Forestry,* p. 625, October, 1920, reference is made to an old belief that cuttings stuck into a potato will strike root if the potato is then planted. The note comes too late for a test of the idea this year at the time of writing. It may be that enzymes of the potato will excite root formation in something so apparently foreign as a tree cutting. We do not as yet know about reactions that horticulturists of to-morrow may bring about in plant physiology.

I. PLANTING FROM SEED

We do not plant nuts with the idea of raising seedling trees. It has been done in years past by men

who did not know what we know about the subject to-day. Nut trees should not be propagated from seed excepting when they are to serve the purpose of grafting stocks. Seedling trees are not desirable for fruiting purposes. They do not come true to varietal type from the seed. They are like apples in this respect. Most of the nut trees are wind pollinated and under such circumstances crossing is occurring so continually that many ancestors are represented in the progeny of any one tree. If we plant the seed of Baldwin apples and Seckel pears we do not get a Baldwin apple or a Seckel pear from the seed. The same is true of a Taylor shagbark or a Hall walnut. As a matter of fact, the progeny of a superior variety may be inferior even to the average type. Nature likes to preserve a sort of average or mean type in all established forms in organic life and the nuts or fruits which serve man's purpose best are rarely those which belong to the mean or average type. The remarkably good ones from man's point of view belong to abnormal forms. Nature sees no particular value in a hickory nut with a very thin shell which would expose it to enemies, yet man chooses that kind of a nut and he reproves Nature for being so indifferent as to make thick-shelled ones. From man's point of view the thin-shelled nut is the one which should have been made in the first place. That is the one which he propagates. The fact that seedling nuts do not breed true to type has not been generally understood. Many men have paid fancy prices for exceptional pecans or shagbark hickories

for planting purposes, not realizing that according to the laws of inheritance many ancestors will appear in young trees growing from these nuts. Some of these ancestors may have borne small thick-shelled nuts. Nuts then are not to be planted in the expectation of developing valuable crop trees. They are to be planted chiefly to serve as stocks which are to be grafted later to kinds which are known to have superior qualities. If a man has speculative instinct and patience, two things which do not quite belong together, he may plant seedling trees and then sit down and wait to see what they will do. After waiting for nineteen years and then finding the whole lot to be inferior for fruiting purposes he may graft the trees all over to good kinds which may bear in two or three years. Hundreds of acres of seedling pecan hickories and seedling Persian walnuts are now on the way to disappoint their owners. A particularly desirable nut or fruit of any sort represents what naturalists call fluctuating variation rather than mutation. In the work of a plant breeder it may be the result of a fortuitous cross. In accordance with known laws the planting of large nuts will give trees bearing nuts of mean or average type for the most part. More important still is the fact that a prolific bearing tree is an exception and most of the seedling trees will not be very productive, productiveness being a special feature of varieties selected for that purpose when we graft.

Nuts which are to be used for planting purposes should be stored over the winter in such a way that

they do not become dried out. Cold storage is desirable if one has access to facilities. The hazels and chestnuts dry out so quickly in ordinary storage that the germ is destroyed, sometimes in the course of a few weeks. A good way for preserving nuts is to stratify them in alternate layers with sand in a box or barrel which is kept in the cellar, preferably at a low temperature. Nuts may be kept in earthenware jars without losing moisture to a dangerous extent, but the jar should not be entirely filled and the top must be removed for a moment from time to time to allow change of air. We must remember that a nut is an organism all full of life promises and that it must breathe quite as well as a red squirrel must breathe although to a lesser extent during the dormant season. If one wishes to plant nuts in the open they may be planted in the autumn, much to the delight of field mice and other rodents unless the facilities are such as to include protection. When planting nuts which have been stored during the winter it is best to put them in the ground as soon as the frost is out sufficiently, allowing them to have the benefit of subsequent freezing and an abundance of early moisture. In order to reproduce natural conditions nuts are not to be completely buried. A striking object lesson in this regard occurred several years ago when I planted a large number of black walnuts about two inches beneath the surface. A few came up in the first year, but more in the second year, and a few of them in the third year, although it is possible that the latter started late in the second

year and were overlooked. I then planted a large number by simply laying them in rows and stepping upon them, leaving a part of the shell exposed to sunlight, freezing and rain. Practically every one of this lot started sprouting within a few days. Nuts which were damp and cold on one side and with alternating sunshine and rain on the other side wanted to get out of that uncomfortable situation promptly. In order to accomplish that it was necessary for them to get into action. A more scientific explanation perhaps would relate to unequal expansion of the shell. Another object lesson in this connection was furnished by some California black walnuts, planted in a wire cage. None of them sprouted in the first or second years. In the third year I dug up a couple and finding them spoiled threw the whole lot out along with some loose dirt and left the heap to be cleaned up later. Here appeared one of the compensations for my careless way of doing things. A number of the walnuts which evidently had not spoiled began to sprout in the loose heap unexpectedly, instead of expectedly in the first year of careful planting as they should have done in order to be conventional and proper according to my way of thinking. We are familiar with the fact that seeds of plants which have been cultivated for centuries usually sprout a few days after planting. We are prone to forget that seeds of wild plants may wait for more than a year for the advent of some combination of temperature, moisture and light before sprouting.

Because of the danger of pleasing field mice if nuts are planted in the fall and in order to avoid stratification as an intermediary step I have constructed a number of galvanized iron wire cages eight inches in depth, three feet or more in length, and about two feet in width, furnished with a lid of the same material. These cages are set in rows to a depth of four or five inches and are then filled to ground level with sandy loam. The nuts are planted in these cages in the fall, preferably. During the winter the nuts are covered with a light mulch of leaves which is removed early in the springtime. A part of the shell of the nut is exposed to changes of temperature, light and moisture, and this has given the best results of any method which I have employed. Although sprouting under the circumstances is doubtless due in part to the unequal contraction and expansion of the exposed part of the shell, that feature would hardly apply to thin-shelled chestnuts. Nuts which have sprouted in the galvanized cage are allowed to grow there for a year, where they may be readily weeded and given a little fertilizer. The only enemies which have attacked them under this sort of protection have been ants and army worms just at the time of sprouting when the shells first burst open. A little dusting with wood ashes has sufficed to drive the ants away without injuring the plants. Army worms will gather under a handful of loose trash during the day and may be removed by hand. Some species of nuts which start into activity with difficulty, like those of the tree

hazel, may be stimulated into development by soaking them for forty-eight hours in cold water and then immersing them for an hour in water as hot as can be borne by the hand. If they are then planted in rows leaving a part of the surface exposed most of the nuts will start.

At one time I thought it best to take the nuts out of the cages as soon as they sprouted and transplant them to nursery rows, but I had one entire lot of several hundred hybrid hazels destroyed by crows and have had so many transplants injured by rodents that it now seems best to keep the nuts for the first year under the protection of the wire cage. Some species, walnuts in particular, sometimes make a growth of two feet or more in the first year, and under such circumstances it is necessary to elevate the lid of the cage and to fasten it permanently open with a stake until the time for transplanting has arrived. Spring transplanting is preferable, because if we transplant in the fall the ground may "heave" in the following spring when the frost goes out and prove to be very destructive to little plants which had not extended their roots deeply. In the second year one may transplant nut trees from the cages to permanent sites or to the nursery row if they are small enough to require weeding and cultivation for a year or two more. The nursery row is perhaps the best place for little trees that are to serve as grafting stocks for other kinds, as it simplifies the matter of convenience in grafting or budding a large series. Nut trees when transplanted to permanent sites require attention for at least two or three years with

regard to hoeing, watering, and fertilizing. As a matter of fact, this process may be continued profitably throughout the entire life of a tree if one is raising nuts with the idea of supplying a market. The time for grafting seedling trees is a matter of choice, but varies widely according to circumstances. Stocks of most nut trees may be grafted at any time after the first year, but preference is commonly given to three-year stocks by nurserymen who graft saplings in the nursery row. Topworking older trees which are established in their permanent sites may be done to advantage until trees are twenty or thirty years old. After that the difficulties of grafting increase very rapidly.

The matter of labeling trees and of keeping crop records for purposes of reference is important. Labels have a most astonishing way of getting lost. In my own work the best labeling method consists in lettering a strip of metal which goes with the Roover machine and then fastening this label with copper wire to a galvanized iron rod set in the ground near the tree. The galvanized rod is clipped from large wire with a pair of strong cutters. It is very durable, as may be attested by hired men who mow before they look. The entire label device is imperishable and cannot be lost unless actually carried away.

2. PLANT PHYSIOLOGY

In connection with the problems of propagation perhaps we may review briefly the essentials of plant

physiology in their bearing upon this part of the subject. The plant takes from the ground only water and mineral salts in solution. These are absorbed chiefly by the young roots and principally by the root hairs of young roots. On that account we need not plant a large unbroken root system when we are transplanting trees. The larger the mass of old roots to be supported the greater the demand that must be made upon the plant for growing a lot of young roots with new root hairs. The green parts of the top of the plant absorb carbon dioxide together with some oxygen and some water vapor; on the other hand they give out carbon dioxide, oxygen, and water vapor. The amount of water vapor given off by a fully developed walnut tree should amount to somewhere between two and three hundred pounds per day according to experiments which have been made with other fruit trees. This relates also to grass and other plants beneath the nut trees. It means that the demand upon soil water is so great that methods for reducing the competition between the nut trees and other plants in the vicinity are in order. In semi-arid regions trees grow so far apart as to represent a parklike aspect. Each tree apparently requires water from a range far beyond that of its spread of limbs. Carbon dioxide, which is taken from the air, is employed by the plant for making chemical combinations with inorganic material taken up by the roots and this is transformed into organic products, carbohydrates and proteins, which are employed for immediate nutrition of the plant in

the course of growth or fruiting or they are stored up for next season's work. In the northern temperate regions food which is manufactured in the leaves is carried in quantity to the roots during the months of July, August, and September. In the springtime the stored food is reconverted into more soluble forms and is then transported to the upper part of the plant to supply the needs of the season's work. Some of the food is used by the roots for their own purposes of increase. The movements of food correspond to sap movements and relate largely to the laws of diffusion. Thus when there is an excess of a mineral salt in the upper part of a plant it would naturally move downward in order to meet the water from the root containing a lesser solution of the salt. We need not at this point go into the elaborate and more complex physiology relating to sap movements. In a young tree nearly all of the food is needed for maintaining life processes and constructing new tissue. When sufficient volume of new tissue has been laid down the plant then acquires a surplus of food and reproduction begins. This explains the earlier fruiting of trees which have had plenty of nourishment in the course of cultivation. It explains in part the earlier bearing of grafted trees, the stocks having an advantage in age over the top. Another reason for early bearing of grafted trees is that bearing branches or branches nearly ready to bear are commonly chosen as grafts. The cell structure of such grafts has become already formed for fruiting purposes.

3. SOIL

Annual plants like radishes and beets which have been subjected to cultivation for very many generations will adapt themselves to almost any soil ranging from heavy clay to light sand. They have become tamed, one might say. The common fruit trees have become tamed pretty well, although the Newtown pippin apple and the Washington navel orange remain aristocratic in their insistence upon having the orchardist consult their tastes in the matter of soil. Nut trees on the whole must still be treated as wild trees. Even those like the Persian walnuts, the hazels, and the chestnuts which have been flung far from their original homes have not been subjected to cultivation in such a way as to largely increase their adaptability to widely different kinds of soil.

Young nut trees of different species should be given, if possible, the sort of soil in which they are known to thrive best when in a wild state. This general principle does not help us in the question of planting orchards upon prairie lands. A good deal of experimentation must be conducted upon certain prairies which in the end may perhaps carry larger nut orchards than are grown elsewhere.

When transplanting young trees the feature of chemical reaction of the soil is important. Some of the hickories, notably the pecan, dislike very much to start off in soil with acid reaction. Most of the walnuts are still more sensitive than the hickories on

that point. When a hole for a transplanted tree is dug a little lime may be sprinkled over the out-turned earth and about the walls of the hole, if the soil shows acid reaction when a piece of blue litmus paper is pressed against it with a stick for testing purposes. Blue litmus paper may be obtained from any drug store. A small piece of the paper pressed against the soft, moist earth will turn red if the soil is acid in reaction. The fingers must not be used to press blue litmus paper against the soil because moisture from the fingers commonly gives acid reaction. Use a stick for making pressure. Blue litmus paper turns red when it is moistened upon an acid soil, but red litmus paper turns blue if the soil is distinctly alkaline in reaction. Almost any young tree which has made a good start in the first two or three years of its life in soil that has been limed will go on to devolp in soil that is moderately acid in reaction after that time, although the trees which prefer a neutral or alkaline soil will never do as well as they would in a soil to their natural liking. Lime will neutralize acid in the soil. Alkalies in the soil do not require attention as a rule.

When transplanting young nut trees the texture of the soil aside from its chemistry has a distinct bearing. In general it is best to pack soil firmly against the roots of young transplanted trees, firming it with a tamper in order to make close contact between root and earth. If close earth contact is not made roots cannot take up moisture and nourishment from the soil freely. With sandy alluvial soils

it is well to pour a bucket of water into the hole in which the young tree is set and then move the little tree up and down a bit until the mud snugly packs about every root. This would be fatal to the tree if attempted in a clay or clay alluvium. The reason for that is that the clay mud sets about the roots in a hard ball that the newly transplanted root cannot penetrate. In some soils a contraction takes place after a young tree has been set in mud so that the earth actually draws away from the roots at various points. The very valuable method of settling the earth about the roots of a young transplanted tree by means of a pail of water must be carefully adapted to soils in which it is really a valuable method and not an injurious one. For the most part a firm tamping of the ground will suffice. The question of adding fertilizer at the time of transplantation is a moot point. Most orchardists, I believe, prefer not to add any manure or other fertilizer aside from lime at the time of setting out the young tree. I have sometimes employed an inch or two of good rich leaf mold at the bottom of the hole, covering it with a bit of ordinary soil, and believe this to be advantageous. A little leaf mold may be added also to the soil which has been turned out of the hole and then turned back in when the soil is replaced about the roots of the tree. Aside from the use of lime and of leaf mold in this way fertilizers or manure are injurious to young trees in the kinds of soil with which I have experimented.

Chestnuts will thrive pretty well in soil that is distinctly acid in reaction and several authors have stated that lime is injurious to trees of the chestnut group. This proved not to be true in the case of three young chestnut trees which I limed experimentally in Connecticut soil. They grew up in the garden where they were not wanted and I tried to kill them with lime, but failed to do so. They seemed to be benefited rather than harmed even when lime was added in proportions believed to be large enough to kill chestnut trees. On the other hand, there is so much good testimony to the statement that lime is injurious to trees of the chestnut group that it should not be used until one has experimented with the soil of his locality.

When planning to change the character of land for purposes of nut tree cultivation we may resort to draining natural soil or irrigating dry soils. We may dynamite hardpan or pull stumps from a timber cutting. Rocky land, however, is best left undisturbed. Rocks collect heat from the sun during the day and radiate heat gradually into the soil during the night. Condensation of ground moisture takes place about rocks and large stones in such a way as to give the roots more moisture than they would otherwise receive. There is a question if very large stumps may not be left to advantage. Their slow decomposition furnishes food for new tree roots and the tops above ground do not interfere with the growth of young nut trees.

4. TRANSPLANTING

The transplanting of nut trees requires more particular attention than does the transplantation of soft wood fruit trees. In preparation for transplanting I personally prefer to cut back the top and root pretty severely. The reason for that is that the young tree when first starting into growth must get its nourishment largely from the stored-up food in the cambium layer of the bark. It begins to work at first upon a diet of little more than plain water from the soil. Later the feeding by way of roots upon nutritious material in the soil must be conducted through root hairs. These dainty silvery root hairs are very quickly dried as a result of a few minutes' exposure of the root to the sunlight or wind. Roots of a transplanted tree will take up water before new feeding roots have developed, but actual progressive growth must await the development of a brand-new set of tiny silvery root hairs. The Stringfellow method consisted in cutting back top and root until nothing but a "turnip of a tree" was left, and this was set in a hole made by a crowbar just large enough to insert the "turnip." I tried out this cruel method and it was successful. It is like planting a great seed half underground and half out. I find myself with conflicting emotions in the matter. The idea of trimming away a beautiful root system and throwing it into the bonfire and then trimming back a fine thrifty growth of grafted top down to one or two buds shocks my

thrift notions to such an extent that I find it very difficult to carry out the close-cut method systematically. No doubt much depends upon soil and climate in relation to this method developed in Texas, but at Stamford, Connecticut, there are several species of trees transplanted by the Stringfellow method which made a first-rate start and growth, even surpassing several trees in which I had been particularly careful to save a nice root and top.

When young trees are first transplanted it is well to give them a mulch of straw litter or of dead leaves for the first two years. In this connection we must remember, however, that mulch is synonymous with mouse. Field mice will make cozy homes in the mulch. In the winter time when food is scarce mice will destroy many trees unless provision is made in advance by whitewashing or painting the trunks near the ground. Wire gauze may be cut into appropriate lengths and tied about the young transplanted trees in localities where field mice or rabbits are particularly abundant. Incidentally, it may be remarked that rabbits and field mice are both pretty good eating. The time may come when shortage of meat foods will lead to our utilization of neglected supplies. It has been suggested that the only way to thoroughly dispose of any one pest is to eat it. Prejudice against the fat field vole is due to the fact that somebody called it a mouse and then refused to eat anything to which such a name had been given, even though it is as good as a reed bird.

If buds have not made a start by early August

in the north it is desirable to place straw or other shading material about the little tree after cutting it back severely and protecting cut surfaces with melted paraffin to prevent drying out. This will have a tendency to avert August starting of buds which would send out tender shoots to be winter killed. A tree is safe if carried over to the second year whenever buds remain dormant in midsummer. The so-called laying over of transplanted trees to the second year or late starting of buds seems to be remedied in the locality of my own grounds by severe cutting back of both root and top at the time of transplanting. This method should be tried out elsewhere to a greater extent than has been customary. The method has not appealed to horticulturists generally because it is directly opposed to their instinctive approval of a large and beautiful root system of the sort pictured in nursery catalogues. The Stringfellow method has been particularly successful with me when transplanting pecans (and incidentally persimmons). Nurserymen have usually taken pains to send on young trees with full top and long roots. If, for example, they had trimmed back five-foot pecans to stubs about eighteen inches in length consisting of top and root about equally balanced they would have avoided much trouble in packing. There would have been less danger of bruising in transit and my only loss would have been that of the tops which I usually cut off promptly and employ for grafting into other stocks. The fresh-cut end of stock is then covered with

melted paraffin to lessen evaporation of sap. When transplanted trees make a late start and their tender shoots are winter killed we are apt to have in the following year a large number of shoots starting tardily because of their springing from small latent buds. This chaplet of many new shoots starting from below the winter-killed part is in turn exposed to winter injury in the north. Inexperienced men have become discouraged because of such unruly behavior on the part of their first tree children. My advice under the circumstances has been about as follows: Try once more. When a young tree has been taken from the nurserymen's package, cut back top and root as far as your heart will allow and then hand the tree over to some enemy and let him cut it again.

The chaplet of many new shoots springing from below a winter-killed part is particularly likely to appear in the Persian walnut. All shoots but one are to be cut away as rapidly as they appear. The one shoot will then make a great growth, leaving much firm wood even though the tip is killed later. By the third year all danger is past and the tree far on its way to success in the world.

What proportion of nut trees will live after they are transplanted if they are completely neglected from the start? I doubt if the number is larger than five per cent. Under thoroughly wild conditions only one seed in many millions ever survives competition and enemies and gets to form a new tree. Perhaps only one among thousands of trees which ac-

tually make a fair start from the seed under wild conditions finally survives. The affectionate gardener who knows each tree by the sound of the music in its leaves at night believes he can save nineteen out of twenty trees and he doubtless does so, but he sets out his trees personally and gives them loving care. The orchardist who gives his trees to be cared for by employees will perhaps not succeed in having more than one-half of the trees live. The question of the proportion of nut trees which will live becomes therefore a largely personal matter depending upon the character and time of the man who has assumed the responsibility for their guidance through life.

Most nut trees will do better than common fruit trees under conditions of neglect after the third year from transplanting. The reason is that fruit trees for the most part have been developed under conditions of cultivation during their youth like those of highly bred animals or of people in the cities. A caribou lies down for a comfortable nap in the snow on a hill top where the wind is blowing forty miles an hour at a temperature far below zero, but a prize Jersey cow begins to sneeze if the wind comes through a crack in the nice warm barn floor. Wild trees and cultivated trees stand in something of this sort of relation to each other.

CHAPTER II

GRAFTING

A REVIEW of the history and literature of tree grafting would seem to indicate that very little has been added to our knowledge of the subject for more than a century. Authors have complimented other authors by accepting their views. They have described clever variations in technique but without adding new principles in the abstract. In this chapter will be found material which promises to revolutionize the whole subject. At the beginning of the twentieth century even so famous a grafter as Mr. Jackson Dawson, of the Arnold Arboretum, had failed with the hickories excepting with a few small specimens grafted under hothouse conditions. At the present time, twenty years later, almost any bright youth may now graft hickory trees in the open almost as readily as apple trees are propagated. Yesterday scions for the coming season's work were cut and stored while buds of the cuttings were dormant. To-day we may cut a scion directly from one tree and place it immediately in another tree at almost any time during the summer in temperate climates. Perhaps it may be well to add to our nomen-

clature by speaking of this latter method as immediate grafting, while the older method may be called mediate grafting. Mediate grafting may continue to be the chief method, but immediate grafting in my experimental work promises to have a field of its own.

The textbooks describe budding and grafting as separate subjects. This leads to some confusion. It seems better to speak of scion grafting and bud grafting, because budding is really a form of grafting and the material in both instances is taken from the same sort of cuttings.

The time for cutting scions for mediate grafting will depend much upon the climate of a locality. In northern temperate regions we avoid the danger of winter injury by making cuttings in late autumn, but, on the other, this means more care in the winter storage of scions. For the most part February cutting is perhaps the most satisfactory. Cuttings may be of any length from six inches up to several feet, but for convenient handling cuttings one or two feet in length are desirable. Very short cuttings dry out more quickly than do the long ones, and a whole limb in storage will remain in good condition with less care than is required for a six-inch scion. Short scions may be cut from such a limb at any time when they are required.

Selection of scion material is very important. Vigorous shoots of the previous season's growth are preferred as a rule. Sometimes, however, a rank growth of pithy shoot is far less desirable than cut-

tings of more solid wood two or three years old if the latter is well endowed with buds. Cuttings from limbs that are already in bearing will fruit more quickly than cuttings from water sprouts or internal shoots that are struggling for position.

Cuttings for immediate scion grafting consist of wood that is not of the season's growth, unless the latter is well matured. Nearly all of the growth of the year is to be trimmed away. Although some of the small buds of the season's growth will occasionally start, we depend upon dormant buds that have held over from a previous season for our best results in immediate scion grafting. These old buds unfold first as a rule in cases in which we have left some of the buds of the season's growth. The reason for this is probably that a certain resting period is required for the bud in accordance with its established physiology.

Immediate bud grafting is different from immediate scion grafting in that it includes the idea of a bud resting until the following season. Bud grafts may be cut to advantage in late summer from the growth of the season and when inserted they are to "lie over" until spring. Immediate scion grafting, on the other hand, includes the idea of having the scion start off into growth in the same season and for that reason it is replaced by bud grafting in the late season.

The matter of preservation of scions for mediate grafting is one requiring a considerable degree of experience. If scions are cut in early winter we

avoid winter injury which sometimes lessens the vitality of those which are cut in February or March. For northern regions, on the whole, it would perhaps be best to cut scions while they are still dormant in the early spring, unless one has facilities for keeping them through the winter in cold storage. When scions have been cut in quantity for the coming season's work they may be kept in cold storage with a little slightly dampened moss tossed about them loosely. Most men engaged in this work will not have such facilities and an excellent method consists in placing a box flat upon the earth of a cellar that is not subject to severe temperature changes. The bottom of the box may be covered with dead leaves collected in the woods, but not wet. A layer of scions placed upon a layer of leaves is covered with more leaves and then another layer of scions alternately but leaving room for at least a foot of dead leaves over all. The top layer, a thick heap of dead leaves, may be pressed down rather firmly with boards and the entire box covered with bags or a blanket. When stored in this way scions will keep very much as Greening apples would keep under similar circumstances. Scions may be covered with sand on the cellar floor in the same way if one does not have too large a quantity to be covered over. Mr. J. F. Jones keeps his scions in sphagnum moss slightly dampened with weak Bordeaux mixture. We must avoid having scions too moist. When they carry a full charge of water a good deal of vital chemistry is going on continually and scions which

have been active in cell work are not in as good condition as those which have been allowed to become a little drier than normal; either extreme is to be avoided, however.

Scions which are carried about the field at the time of grafting may be wrapped in any sort of waterproofed material along with a very little damp moss. If this is not done they will dry out seriously in the course of a few hours' exposure to the air on a warm or windy day with high barometer. One of my acquaintances who grafts a very large number of chestnut trees every year simply places his bundles of scions in an eighty-pound milk can and puts on the cover, storing the milk can in a cool place where alternate freezing and thawing would be avoided. Evaporation of moisture does not take place readily, and water, he says, does not get into a milk can used for scions alone. I have sometimes kept small lots of scions for a couple of months in the springtime in an ordinary glass jar with a loose cover, not hermetically sealed. Dip the cut ends of the scions in melted paraffin before putting scions in storage of any sort. When using scions prepared in this way I have frequently found bright green cambium layer clear down to the wax and a collar of callus protruding. Scions not so protected might have an inch or more of discolored wood at the cut end when they were taken out in the springtime.

On my country property at Stamford the ice house has been a convenient place for storing scions of the customary foot or two in length, up to large branches

that were sawed off and placed whole under the sawdust. It was my supposition that the low temperature and the moisture near the ice layer kept this material in good condition. Two years ago the winter was so mild that no ice could be cut, but scions buried in the sawdust seemed to keep quite as well as if the ice had been there. A certain amount of ground moisture made its way into the sawdust and this sufficed. In that year scions kept well enough so that hickories grafted as late as the last week in July and hazels as late as the first week in August caught and grew successfully. At the time when scions are to be grafted it is important for the buds to be dormant as a rule. Hazel scions may be used after the buds are opening, even after tiny leaves have appeared, if we cut off most of the opened buds and cover the bud stumps with paraffin. The hazels are an exception, however. Buds of other species which have made a start when the graft is inserted will often go on unfolding in the most charming way but on false promise. They grow for the same reason that they would grow in a glass of water. In other words, it is the water of the stock sap that is forcing these buds into activity before union has taken place between stock and scion. Their only nourishment is the small amount stored up in the scion itself. If scion buds are completely dormant when the graft is inserted there is time enough for cell union between stock and scion. When this has taken place before the buds make a start they are then ready to receive

abundant nourishment from the stock instead of just water. It may be that some other swelling buds besides those of the hazels may be treated successfully by cutting them in half and covering the bud stump with paraffin. The cutting back of a bud and covering the stump with paraffin appears to hold back growth for a long enough time until graft union can take place in the case of the hazels.

Scions which come from a long distance by mail are usually found to be either too dry or too moist when they are received. The proper packing material has not been employed. Loose moss of the sort to be obtained from a florist or in the woods may be very slightly dampened and distributed among the scions. Waterproof paper will serve for the first layer of wrapping and then over all strong coarse paper finishes the package. If no moss is available soft cloth slightly moistened may be used in its place. I have experimented to a limited degree by covering scions completely with melted paraffin. This served to keep them in good condition for several weeks without other protection than a covering of dry sawdust. The method may perhaps be extended for preparation of cuttings that are to be sent on long journeys by mail. Scions which are to be used for mediate grafting will make a good start if they are a bit drier than normal when put in place. Bud grafting, however, introduces a question of getting the bark away from the wood of a cutting if the material has been long in storage. When a cutting is found to be "barkbound" the bark

may be made to slip by immersion of the cutting in cold water overnight and then subjecting it to a few minutes of immersion in water as hot as may be borne by the hand.

In the nursery young seedling stocks which have been planted two or three feet apart are cut down to any desirable height at the moment of scion grafting. On the other hand, when bud grafting is to be the choice in method the seedlings are not cut back immediately. We wait until the bud has been accepted as a welcome guest and is firmly grown in. The top of the seedling is then cut off a short distance above the bud graft at the time when we wish the bud to start. This may be done in the course of a fortnight or so in spring bud grafting, but in fall bud grafting we allow a bud to remain dormant and the top of the stock is not cut down until spring. The cut end of the stock in either case is covered with paraffin to prevent evaporation of sap and to avert waste of energy of the sapling in making wound repair and protection.

Preparation of trees larger than those in the nursery row may often by done to advantage at some time in advance of the grafting season. In the latitude of New York a good time for cutting back trees for top-working purposes in in February. Wounds heal better then than at other times during the winter months or after the sap is flowing freely in early spring. Three-fifths or even four-fifths of the top of a tree may be removed without causing much shock in February. The cut ends of branches

are all to be covered at once with white lead paint for the larger wounds. Paraffin is best for the smaller ones in the author's experience. When the limbs of a tree are cut back in the winter preparatory for spring grafting if the rough sawed ends are trimmed neatly with a sharp knife and then covered with paraffin they remain brightly alive clear to the tip and are ready to receive end grafts.

The question as to top-working a tree or cutting it down completely and then grafting the lively shoots springing from the stump is one which requires further experimentation. With the chestnut it has been worked out successfully but only in a limited way as yet with other trees. Very old trees if cut down are not likely to send up new shoots from the roots. They are discouraged by failure in business late in life. Young and vigorous trees, not more than a foot in diameter, may be cut down in the winter time in the expectation of their sending up a glorious new lot of shoots. When grafting these sprouts we must remember that a very large root system must be nourished. It is inadvisable to subject the entire series of shoots to grafting. It is better to graft only one or two shoots from the stump and then allow natural shoots upon the opposite side of the stump to grow rapidly and to take charge of the nurture of the root system until the grafted shoots have themselves grown to dimensions which will allow us to cut out natural shoots one after another for two or three years or more. In this way a good balance between top and root

is maintained. When a tree has been cut down completely we may often save a year of time by inserting a bark slot graft in the following grafting season. This will sometimes avoid the necessity for doing any sprout grafting a year later. The whole cut end of the stump is to be painted and all of the natural shoots may be allowed to grow during the first year if the graft shoot has made a vivacious start. On the whole, it is far better to cut back three- or four-fifths of the top of a tree in preparation for grafting instead of cutting the tree down. A good many years are required for the root system to recover from the shock of such severe treatment. On the other hand, the trimming of the top means more work on the part of the grafter, but the tree will start off all full of enthusiasm in an effort to regain its beauty and symmetry. When trimming back the top of a tree it is well to leave as many small internal branches as possible. These are easily grafted and require less labor than the grafting of cut ends of large branches. The foregoing remarks apply to trees which are to be top-worked by mediate scion grafting. Mediate or immediate scion grafting in the summertime calls for more severe cutting back of a tree in full leaf and busy with its affairs of growth. Any plant physiologist knows that this means a good deal of shock and yet I find practically that trees bear the ordeal bravely. Sometimes the entire leafy top of a tree has been removed in midsummer and yet when grafted at once the graft shoots and new natural shoots have put out flourish-

ingly before autumn. There is a tendency for such a tree to be too ambitious and to grow its new crop of shoots right up into freezing weather. For either mediate or immediate summer grafting my experience to date includes the idea of leaving one good sized top branch unharmed and of grafting the stubs of all cut branches below that point. The top branch may be sawed off one or two years later, and in falling it is pretty sure to rake out some very beautiful grafts as a farewell expression of its sentiment toward the whole procedure. The question of the size of the sap leader (the branch to be left at the top) is one requiring a good deal of judgment. If it is too large the tree retains a spirit of contentment and may not send new shoots into activity. If the sap leader is too small it may not maintain nourishment of the root system sufficiently to make the best gain on the whole. This point is one requiring so much judgment and relates to particular varieties of trees in such a way that no rules are to be laid down. Sometimes in summer grafting when nothing but a small sap leader has been left, the leaves turn brown shortly and die, buds mature, the branch takes a rest for a few days and then starts off into new activity. As yet I have no explanation for this phenomenon. In a speculative way one thinks of bursting of cells in leaves from extra sap pressure or perhaps of enzymic poisoning of the cells in the leaves by materials which would ordinarily be eliminated by excretion processes. The top-working of very large trees includes the idea of so much labor that it is

not recommended for amateurs. A dignified shagbark hickory tree about sixty years of age that I cut back for grafting purpose about three years ago is not half grafted as yet, and it is inclined to resent the indignity imposed upon it by giving chief attention to its own independent new shoots with scant courtesy extended to the grafts. Any man who tries to defeat Nature is likely to find himself much occupied with details of the effort.

The preparation of nut trees for top-working will be most satisfactory if confined to those which are less than thirty years of age. Even then the first labor involved is considerable, but it pays. Let us take for example an old field containing a couple of wild hickory trees, a black walnut and a butternut. If the owner cuts these down and puts the field into rye he will probably get about twelve bushels of grain and a ton and a half of straw to the acre, yielding beyond all expenses perhaps twenty-five dollars net profit. The labor and cost of annual preparation of the field for other crops will seldom give more than fifty dollars net profit to the acre at best. If the owner of that field top-works the four wild trees with scions of fine market varieties instead of cutting them down and putting annual crops in the field, his first cost will perhaps be twenty-five dollars per tree and he would have to wait for as long a time as he would for so many apple trees to come into profitable bearing. The four trees, however, when in good bearing may easily yield an average of one hundred dollars net profit on nuts annually. The

owner instead of devoting a great deal of time and hard labor to raising and collecting his crop will have abundant time for going to town and interesting himself in civic affairs.

A large new field of observation will relate to the selection of nut bearing grafting stocks. Which ones will furnish dwarf nut trees, which ones will give prolific bearing, which ones will increase the range of soils in which a certain choice variety may be raised—these and other questions remain to be settled and increase the interest in the subject of nut culture at the present moment.

A species of tree with a top naturally smaller than that of the stock upon which it is grafted may not be fruitful. After the time when top and stock balance each other the stock demands so much from the top in the way of nourishment that little fruiting energy may be left. Species of other hickories grafted upon pecan stocks furnish an example, but some of the hazels make an exception. On the other hand, a top naturally larger than that of the stock finds it an easy matter to satisfy the root of the stock and we have prolific bearing. Apples and pears grafted upon dwarfing stocks furnish an example. The pecan hickory when grafted upon the water hickory will sometimes grow rapidly for a few years and then die back if the stock stands where its feet are very wet, but on higher land this is said not to be the case.

When using the various hybrid hickories as scions we shall have to learn which parent species gives the

most promising stock. This has not as yet been worked out excepting for nursery trees in very recent years. There will be many advantages in finding a range of stocks upon which any one species may be best grown. For instance, the shagbark grafted upon the bitternut may bear in low or very swampy ground, where most of the hickories will not grow, and if the same shagbark will grow upon the stock of the mockernut in poor dry soils, shagbark hickories may then be raised in thin sandy soils in which the mockernut is often very thrifty.

The Persian walnut apparently takes very kindly to the black walnut as a stock tree. This gives the Persian walnut a wider range than it would otherwise have because the Persian walnut prefers a soil that is neutral or alkaline and is rather intolerant of soils with acid reaction. The black walnut, on the other hand, will not simply grow in acid soils but will sometimes thrive in soils of such reaction, thus increasing the range of the Persian walnut. Furthermore, the Persian walnut root is a favorite with the field mice which burrow about the roots, sometimes injuring the roots very seriously. Field mice seem to care very little for the root of the black walnut and this gives an added advantage. I did not realize the extent to which field mice fed upon the root bark of walnuts and on some of the hickories until I had occasion to dig down to the roots for experimental root grafting. The roots of the Persian walnut, bitternut, and butternut were sometimes found to have been stripped of bark for

such a distance that it was difficult to find uninjured bark for doing root grafting. The old scars apparently represented many winters of feeding of field mice. Several fungi, notably armillaria, attack the roots of the Persian walnut in a destructive way, but the black walnut root has a high degree of immunity to attacks of fungi.

The question of choice of stock is something to be developed gradually through experience. An object lesson consisted in an experiment in top-working two hickory trees situated only a few yards apart; each about thirty feet high. One was a bitternut, the other a smooth-bark pignut. All of the branches of both with the exception of a top branch were cut off and the stubs grafted with Beaver hybrid on June fifteenth. Practically every one of the grafts placed on the bitternut stock made exceptional growth. Almost every one of the grafts set upon the pignut started to grow and then all died back when they were less than three inches in length. This indicates that the bitternut was an excellent stock and the pignut a very poor one for top working with this particular hybrid (a cross between the bitternut and shagbark). The Beaver hybrid grafted upon shagbark does very well, but chooses by preference its bitternut ancestor. In the case of the Beaver hybrid just quoted caprice was shown. It was accepted eagerly by a host representing one of its parents. It was refused as a guest by the pignut which did not represent either one of its parents. The pignut stock, however, would have accepted

shagbark scions—the shagbark representing the other parent of the Beaver. This sort of experience throws open the entire subject in such a large way as to show what possibilities of success and failure lie before us in experimental work. The same method of grafting was employed for these two trees which were neighbors and both trees were top-worked on the same day.

Hybrid nut trees apparently lend themselves to grafting much more readily than do species or varieties of species. This probably means that nature wishes to maintain the identity of a species or variety and resents to some extent our combinations made by grafting. When a tree, however, has lost its identity through becoming a hybrid, family pride is lost. The tree then maintains little race prejudice or class prejudice. Hybrid hickories generally catch readily upon the stock of the species or variety of either parent, and also upon other species in many cases. This opens up a great new field for observation in selection of best grafting stocks. Some hybrid trees make remarkable growth but with little tendency toward bearing. These barren trees, however, seem particularly receptive of grafts from trees which bear in a prolific way. We may therefore combine advantages of strong rapid growth with those of fruitfulness.

As a rule grafts are accepted best by stocks of closely allied varieties. After that by closely allied species, but not so freely by genera. Occasionally we have done successful grafting between genera,

but the farther removed the stock is from the grafting varieties the less success we have on general principles. This is doubtless due to the fact that the food supply required for root and top is most satisfactorily elaborated by roots and tops closely allied. The Japanese sometimes graft widely separated species successfully, but we do not as yet know the limitations. I have grafted chestnuts on several species of oaks and have had them grow thriftily on red oak for two years, but the structure of the wood of the chestnuts and oaks is so different in character that firm ligneous union does not seem to occur and grafts are readily blown away in a heavy wind. Chestnuts are prone to make incomplete woody union even when grafted upon closely allied varieties and species of chestnuts. I top worked a Chinese chestnut tree with grafts of the American sweet chestnut on one occasion and during the early part of the season the American chestnut grafts made tremendous growth; shoots several feet in length in some cases. All at once these began to wilt back without known cause. I found on making sections for microscopic examination that union was not sufficient between graft and stock. The callus had allowed very rapid development of the shoots up to a certain point and then refused to grow them further. There were four exceptions among the grafts on this tree. On examining these four grafts which remained thrifty I found that some insect had injured the terminal bud when the shoots were less than a foot in length and the scion had to wait in this case

a fortnight or more for a new leader bud to start. Apparently the tree had utilized this opportunity for repairing the wound so securely that the tree was quite willing to maintain scions after that time. Taking a hint from this experiment I have since that time found it an advantage to pinch off the tops of rapidly growing chestnut sprouts before the shoots have reached a foot in length.

The influence of stock upon scion and vice versa is commonly supposed to be nothing more than a relation of host and guest, each retaining its identity as a species. As marked an influence as that of the Royal walnut upon the black walnut stock may perhaps occur without loss of identity on the part of host or guest. On the other hand, a pecan tree nearly one foot in diameter near the ground growing at Morgan City, Louisiana, on the grounds of Mr. B. M. Young, was top-worked with a McCallister hybrid. The McCallister, supposed to be a pecan shellbark hybrid, has a very shaggy bark while the pecan does not have bark of that sort. Grafts were put into this top-worked tree at a height of twelve or fourteen feet. They soon caused the pecan trunk of the tree to become shaggy. This would indicate that hormones manufactured by the top may exert profound influence on the entire trunk and root system. The name hormone is given to a group of secretions belonging to animal and to vegetable life. They enter the blood or sap currents and travel about in the circulation giving instructions to cells which manufacture another group of secretions, the

enzymes. They act as stimulating or repressive agents in connection with various activities of organs of animals and plants. This Morgan City tree probably belongs to the group of "hybrids by grafting." That point cannot be determined accurately without cutting off the grafted top and then noting if sprouts from the pecan stock bear hybrid nuts instead of pecans later, due to a changed hormone perhaps.

As a rule graft and stock retain their identity, but in some cases the graft changes the stock. The physiology of the graft-hybrid is not as yet understood, but we may perhaps speculate upon the possibility of enzymes from the stock or graft exerting an influence upon growing embryonic cells in such a way that they develop in response to influences belonging to both parents. A practical application of the influence of stock upon graft and vice versa was noted by the orange growers of the south who found that the Satsuma orange grafted upon trifoliate orange stock bore solid juicy fruit, while the same variety when grafted upon wild sour orange stock bore fruit which was raggy.

Every variety of apple produces its own kind of roots without reference to the kind of seedling stock upon which it is grafted, according to the late Professor John Craig. The scion overrules the natural roots in apples when the budding or grafting is done upon stocks only one or two years of age. This overruling is done evidently by top hormones influencing enzyes below, which determine the character of the root growth. Nut trees may act like

apple trees in this regard and present a phase of grafting by hybridization perhaps. In an older top-worked tree, however, with an established root system, the hormones elaborated in the top presumably find greater difficulty in changing the character of the root. When grafting different species of nut trees it will be well to bear in mind that varieties or species for union purposes should have wood of approximately similar texture. When the stock and scion unite the union is mechanical in its nature rather than physiological. The different life types or character of the scion and stock do not fuse as a rule. If the type of cell in the stock is very different from the type of cell in the scion the union is not satisfactory either for transformation of food material or for stability of union.

In northern temperate climates the chosen time for scion grafting has usually been in the early spring while bud grafting has been done in the latter part of summer. In the springtime the cambium layer of the bark is very actively engaged in conducting new growth and making repair of wounds. During mid-summer and early fall division of cambium cells goes on tardily, but in the buds themselves there is at this time a larger embryonic growth than there is in the spring. The separate seasons for scion grafting and for bud grafting date back to a period so remote that in all probability there was no question of plant physiology in the minds of the older horticulturists. Doubtless a general recognition of the fact of spring activity in plants served

as a guide. In late summer bud grafting could be done leisurely and with economy of bud material.

Bud grafting in the fall has been largely a matter of convenience at a time when the work might be done leisurely, but there are certain fundamental principles involved also. Water requirements are small when the tree is resting from growth activities. This lessens the danger from desiccation of the graft. The operation of bud grafting stimulates cambial activity locally for purposes of repair sufficient for catching and holding a bud graft, but not sufficient for catching and holding a scion graft of the length commonly used until the new method of grafting allowed us to use a scion of almost any ordinary length in summer grafting. The shorter the scion the better its chances as a rule, even with the new procedure in late season scion grafting. The bud graft and the scion graft shoot out buds promptly until late in the summer. After that time the bud graft remains dormant until spring and the scion graft desiccates unless it is very short and thickly paraffined.

When a plant has been wounded in the course of grafting or by accident repair will go on to some extent at almost any time of the year, but callusing for reparative purposes is most active in the spring and early summer. This is no doubt due in part to the degree of water pressure at that season if we are to judge from the fact that in humid regions in the tropics callus forms abundantly at any time. In northern temperate regions scion grafting succeeds

best on the whole during the spring and early summer, but one may graft fruit or nut trees satisfactorily well up toward August. It is observed that the proportion of scion catches is continually less as late weeks go by. This is not true, however, of bud grafting. Buds will catch easily until the stock trees become "bark-bound" in autumn, a technical expression relating to the time when the bark no longer slips readily when cut. In the early spring some of the nut trees, walnuts particularly, bleed so freely that we have to wait until the development of leaves has depleted the supply of water, introducing lower pressure, in order to obtain good results.

The new method of grafting has extended the scion grafting season several months, apparently. Formerly there was hurry to get all of the grafts in while tree buds were bursting in the spring. During the season of 1919, however, under the new method, hickories were grafted by the author from February eighth up to August sixth experimentally. The earliest grafts to catch were those placed late in March. The last grafts which caught well in a practical way were put in on July twenty-first. After that the proportion of catches was small and the growth feeble. Incidentally it may be remarked that hazels grafted with scions as late as August sixth made flourishing growth but were winter-killed later. The scions employed had been cut in late winter and stored in the sawdust of the ice house. In July experiments were tried with grafting immediately from one tree to another, using wood of the season's

growth. This worked well with chestnuts and hazels, but not with hickories or walnuts, only a few out of many immediate hickory grafts catching. The few, however, are significant and I hope to work out principles which will allow of immediate grafting of hickories as readily as it may be done with the hazels. Several of the immediate walnut grafts made a good growth at first and then died before autumn.

Immediate scion grafting in the summer time presents a feature of the author's experimental work which is too new for valuable data. Scions consisting of herbaceous growth of the year have been inserted into both herbaceous growth of the stock and into older wood of the stock but without encouraging result. Immediate grafting of scions of one or two-year-old wood, however, proved to be very interesting. Scions of chestnut and of hazel cut from one tree and placed at once upon another tree caught nearly as freely as they would have done if dormant scions had been used. Care was taken to select scions carrying old, well-developed, resting buds, but as a matter of fact some of the small annual ring scale buds made a good start. All leaves and the growth of the year was trimmed away as a rule from the scions used for immediate summer grafting, as it was found that new buds of the year were not the ones favored by nature for new growth. Although hickories and walnuts did not do as well as chestnuts and hazels in immediate summer grafting they did well enough to show possibilities under the paraffin

method of grafting. Previous to the development of this method all of the author's immediate grafting in summer was a complete failure.

Bud grafting on the whole is preferable to scion grafting after the middle of July in the latitude of New York. The buds usually remain dormant and do not start off into growth until the following spring, thus averting the danger of winter-killing of new sappy shoots.

Scion grafts which are inserted in February and March make tardy start and they are outgrown by May grafts placed upon stock of the same sort, according to the author's experience to date. This observation may not hold good with further experimentation.

If we graft a tree in the spring at the time when sap is running most freely, the buds of the scion will sometimes start into activity purely from the supply of water in the sap before wound repair has taken place and before proper nourishment from metabolized food can be carried to the buds. Under such circumstances the starting buds will die, but by that time the free flow of sap in the tree will probably have ceased and a second grafting may be successful a few days later. When sap is running very freely the lower scions in a top-worked tree are likely to shoot first with a water start. The top scions may do better. Later in the season the topmost scions often start first and grow most thriftily. When sap is running freely the bark of many trees is seriously injured by the soles of boots or shoes of men en-

gaged in top-working. Such injury may be avoided if we wear rubber-soled shoes or leather soles equipped with rubber "air-peds." The latter are valuable for preventing slipping or loss of foothold when we are doing "up-tree" work of any sort.

If for any reason grafting must be done at a time when sap is running very freely there are two ways for gaining advantage. We may graft after sunset when sap pressure falls rapidly, or at this same time we may go over the day's work and touch up leaking points with more paraffin while they are temporarily dry. In the morning sap will fail to break through the hard paraffin.

Before taking up the method of grafting in detail a word must be said about other methods of propagating choice varieties of nut trees. Layering of branches by bending them to the ground and fastening them there until roots have appeared from buried buds or from cut spaces in the bark has been a favorite method with hazel growers for a very long time. This plan was followed in my own work with hazels at first. Grafting by the new method is now so successful that layering has been abandoned. Grafting avoids a good deal of labor and it allows us to save for a hazel tree the energy which would otherwise be expended upon shoots for layering purposes.

Experiments with the growing of nut trees by root or branch cuttings were under way when the easier method of grafting was developed and the experiments were then discontinued. It was found

that hickories, hazels and beeches in particular would grow freely from root cuttings under ordinary field conditions if care was taken to give the cuttings moisture enough. Sections of root varying from six inches up to three feet in length were planted at a slant beneath the ground, allowing half an inch or so of one end to protrude. Numerous sprouts would appear shortly and one only was allowed to grow, the other being pinched off. Root cuttings were sprouted also in large glass jars with a loose top. Sections of root were placed in upright position against the glass sides of the jar. The jar was then filled loosely with living sphagnum moss and placed upon a sunny window sill. Carbon dioxide settles in the bottom of such a jar. It must be blown out occasionally unless oxygen is furnished artificially.

Hazel branch cuttings will occasionally strike root if they are placed in the ground after the manner of rose slips. The only other nut tree cuttings which I have made to grow in this way are those of the alderleaf chestnut. The experiment was tried with nearly all of the nut trees belonging to the latitude of Connecticut. Doubtless cuttings from many other species would have been made to grow under suitable conditions such as may be furnished in a hothouse with beds of earth steam-heated and an abundance of moisture in the air. I planned to have this work done experimentally in conjunction with Professor John Craig, of Cornell University, shortly before his death. In the death of Professor Craig nut culture has lost one of its most valuable expo-

nents at a critical time in its history. He established a course in nuciculture at Cornell University and was laying plans for the sort of experimental work which can be carried out to advantage by a team of students under the direction of a guiding hand. The author at this time established at Cornell a collection of the edible nuts of the world which is now on public exhibition in the College of Agriculture.

Mr. Frederick V. Coville, of the U. S. Department of Agriculture, has suggested that scions be prepared for rooting purposes by girdling twigs in early autumn and taking off one-half inch of bark, the upper cut beginning one-quarter inch below a bud. The scions so prepared are from four to eight inches in length. The principle includes the idea of having a large amount of reparation material thrown out from the cambium layer of the scion and sufficiently suberized to give protection against microbic enemies when scions are to be planted later for rooting purposes. This method of preparation of scions would theoretically result in an increase in the amount of organic food stored up in the stems above the girdled point, for the reason that food elaborated by the leaves would remain in the girdled twig which could not send its supply of food down to the general storehouse of the whole tree. The quantitative increase in organic food in the stems would probably result in qualitative changes in the character of the food supply stored up in the girdled twig, transforming the twig into a sort of seed. A somewhat similar process occurs naturally in the black willow,

which purposely suberizes the bases of twigs of the year. Many of these blow off, take root, and act as a means for increase of the species.

At the moment of writing I cannot find reference to the published report of an incident which is worthy of attention. A large pecan limb torn off in a spring hurricane and driven forcibly into the ground is said to have taken root and to be growing thriftily several years after the occurrence. If one pecan limb can act in this way it is a fair presumption that the horticulturist may eventually grow other nut trees in this way, provided that he can find the principle that is involved without feeling called upon to furnish hurricanes for the purpose.

In the question of wounds, accidental or for purposes of grafting, we have to deal with processes of repair and with obstacles to repair in plant surgery quite as well as in animal surgery. The principles of animal surgery have been developed to a very high degree because of the direct and immediate consequence of neglect of such principles when man or his domesticated animals are involved. We are now entering upon a quite new era in plant surgery. It will be similar to animal surgery at many points of contact for the reason that plants and animals are colloid machines. All of their functions are colloid functions, dependent upon protoplasm, which is the organic unit of all life, animal or vegetable. Protoplasm conducts growth, makes repair, guards against enemies and attends to nuptial

affairs and fruitfulness of the tree as it does with animals.

When a tree has received a cut, materials for purposes of repair are sent to that point in the tree. The tree, conscious and alive to a recognition of its needs, elaborates special material for repair purposes, somewhat different from that belonging to material for growth purposes. The tree sends protective material to wounds along with repair material (protection against interference from microbes). Microbes immediately begin to attack wood, sap, and stored food at the site of a cut. They attack also the materials newly thrown out for purposes of repair because all of these things belong to their own breakfast and dinner. Microbes are both bacterial and fungous. In grafting work we are obliged to consider this point in order to lessen as far as possible the dangers from microbic attack, constituting the grafter's chief trouble. Antiseptics are not commonly used in plant grafting work as they are in animal surgery, but a weak solution of copper salts would undoubtedly halt the development of many fungous microbes. We shall carry antiseptic or aseptic surgery farther than it has been carried previously in our plant surgery of to-morrow. If the wound in the tree has been covered with white lead paint or with melted paraffin, mechanical obstruction is offered to the entrance of microbes into sap and other organic materials which would serve as a land of milk and honey for them.

Aside from direct obstruction to the entrance of microbes into a tree wound melted paraffin goes still farther into the field of aseptic surgery. It occupies interstices in which sap might collect and ferment, yet at the same time allows new repair cells of the wound to shoot along beneath it safely under cover.

According to laws of symmetry the parts of a tree are systematically arranged about the long axis of the tree and about the long axis of a branch, twig, or bud. If a spiral line is drawn about a twig it will be observed that a definite series of buds occurs along the spiral line. The number of buds to a complete spiral varies with the genus or species. This fact is worthy of note in relation to our newer knowledge relating to axial polarity (the sending of sap contents to definite points in the long or short axis of a branch). It is not unlikely that in bud or scion grafting it may be well to set grafts according to the spiral which relates to the series of that particular kind of tree if we wish to reproduce natural conditions most nearly. Sap distribution with its nutrient material is sent along definite lines of the tree for definite purpose and polarity in relation to hormones carried by the sap for stimulating growth or for repressing growth is a factor which is perhaps to be reckoned with in relation to points at which grafts may be set to best advantage.

Nut trees may be grafted according to principles which apply to fruit trees in general but special knowledge is required. Most of the attempts at grafting nut trees were a failure excepting with

almonds until about the beginning of the present century in America. The most extensive experiments were conducted at first in the south with the pecan, with a record mostly of failure at first. In California extensive experiments and expensive failures followed the early history of walnut grafting. In the northeast many men attempted grafting the shagbark hickory but almost always with failure. The chestnuts lent themselves to grafting readily, but not many orchards of grafted chestnuts began to appear in this country before the beginning of the present century. Hazels could be propagated by layering, but early attempts at grafting hazels were a failure. At the present time we may graft all of the nut trees successfully.

The late Mr. Henry Hales, of Ridgewood, New Jersey, made praiseworthy attempts at propagating a remarkable shagbark growing upon his property and now known as the Hales' variety. He sent many hundreds of scions to different nurserymen during a period of years, but with a result of almost complete failure. The dogged persistence of Mr. Hales has become a matter of history. What a pity that he could not have lived to see his prediction come true—that somebody would graft hickories successfully.

The best step forward in grafting method was one that I obtained from a pioneer in successful nut tree grafting, Mr. J. F. Jones, of Lancaster, Pennsylvania, who states that he obtained the method from Mr. E. A. Riehl, of Godfrey, Illinois, the originator

of the idea. This method consists in covering the entire graft, buds and all, with melted grafting wax. Buds when sprouting make their way through the hard grafting wax without any difficulty. The wax used by Mr. Jones contained lamp black, and that used by Mr. Riehl consisted of a beeswax and resin mixture. It was found that these were successfully applicable in the north but not so freely farther south in the hotter sun. Examining into the reasons for this there seemed to be a probability that the black grafting wax of Mr. Jones and the brown or amber grafting wax of Mr. Riehl would naturally allow the heat ray from the sun to pass through to the graft while halting the actinic ray of light. The latter is extremely valuable for promoting the activity of bud chlorophyl, which acts only in the presence of light and in the best way in the best light. Furthermore, the heat rays would doubtless have certain destructive qualities at times. With this theoretical idea of the situation in mind I employed melted paraffin in place of the grafting wax, covering the scions, buds and all, as well as the wound in the stock and the wrappings, with translucent paraffin. This immediately proved to be a success. In fact it appears to have changed the entire subject of grafting in such a way that almost any one employing this method may now do any sort of tree grafting. Melted paraffin fills the interstices in which sap might collect and ferment but at the same time hardening so quickly that it does not introduce the danger of a mechanical obstacle between points of

contact of scion and stock. The second point of value consists in allowing the actinic ray in the sunlight to act upon the chlorophyl in bud and bark of the scion and it does not attract the destructive heat ray. This is due to the translucency of the paraffin. Certain embryonic cells become changed into cells with different functions in the course of growth of a plant. Some of these cells are grouped under one class of what we call chromatophores in parts of the plant which are exposed to the light. The chromatophores commonly develop into chlorophyl bodies or chloroplasts and the translucent paraffin allows light energy to set them at work. Chemical life processes of the plant depend upon the activity of the chlorophyl to such a degree that the translucency of the protective covering for the scion in the new grafting method seems to be important. Third, the paraffin coating, impervious to air, maintains sap tension equally in the course of fluctuation between negative and positive pressures occurring between night and day under varying conditions of light and temperature. This maintenance of equalized sap tension I believe to be important. Fourth, the paraffin is waterproof and prevents evaporation from the scion, which is otherwise prone to dry out before granulation of the wound has taken place in the hickory or in other species which callus slowly. Fifth, under a paraffin coating of stock and scion the plant apparently does not have that impulse which might otherwise lead it to introduce the protective feature of what is called suberization, the spreading

of a corky layer over the wound surface between stock and scion. Corky cells introduce a mechanical obstacle to union.

In the epidermis of all parts of the plant which are exposed to the air are minute openings called stomata, in addition to the larger lenticles. It is the knowledge of this fact perhaps that has prevented botanists and horticulturists in the past from covering a graft completely with a material that is impervious to air and moisture. In actual practice I have found that this interference with respiration of the graft is not of practical importance. The respiration of the stock attends to the matter of metabolism and the scion is taken care of. Reparative and nutrient materials together with enzymes for stimulating growth are sent into the scion from the stock irrespective of interference with respiration of the scion itself.

Experimentally, I have used scions from half an inch in length up to some that were beyond two feet in length, all of which grew when covered with impervious paraffin. At the moment of writing I regret not having experimented with scions several feet in length. This will be done next season. In the north it is not necessary to cover paraffined grafts with a paper bag.

The extent to which the new method will change our ideas on the subject of fruit tree grafting cannot be foretold. In August of the present year of writing my gardener accidentally broke off the top of a young dwarf pear tree. This top was kicked

about under foot in the path for two or three days. Its leaves were wilted as it had lain unprotected in the sun. One of my acquaintances jokingly remarked on passing the spot that perhaps that top would make good grafting material. Taking him at his suggestion, I cut three scions from the wilted top, each about two inches in length, pulled off the dead leaves and grafted the cuttings into a small seedling pear tree near at hand. One of the three grafts promptly pushed out its buds and made a fine strong growth sufficient to insure winter protection at the time of first frost in October. Such an occurrence is out of line with ordinary experience for three reasons. The grafting was done in August. It was done with scions cut from a wilted branch and it was done with wood of the season's growth. Archæologists may find a Sumerian tablet describing this sort of experience, but it would seem to belong to a fresh field of work.

The reason for melted grafting wax of any sort not coming into general practice in nut tree grafting earlier was because it is not required for most other kinds of fruit tree grafting. Having observed the desirability of using melted paraffin for nut tree grafting we may now turn about and apply it to ordinary fruit tree grafting. Another reason for melted grafting wax not being used generally is because of the difficulty in keeping the melted wax at the right temperature. Almost all of the devices which have been employed for the purpose are cumbersome or unhandy. They carry melted grafting wax that is

either too hot or at the point of congealing. These conditions alternated in a most annoying way in the course of a day's work. There has now been devised an apparatus consisting of a deep cup which is sunk into the globe of a lantern. Alcohol instead of oil is used for the flame. Alcohol burns without smoke and the wick may be turned up or down in such a way as to keep the melted wax at exactly the temperature desired on cold days, hot days, and windy days. Two or three ounces of alcohol fuel suffice for a day's work with one melter. The handle of the melter allows it to be hung on neighboring branches of a tree when we are top-working. A railroad lantern model is employed and the metal ribs prevent damage from breaking of the globe. Its broad base allows it to stand upon uneven ground. The name Merribrooke Melter has been given to this transformed lantern. It is manufactured by the Armspear Manufacturing Company, and may be obtained from the distributors, Tyson Brothers, Flora Dale, Pennsylvania. (Fig. 29.)

The Devoe and Raynolds Company of New York, make the "H. H. Grafting Brush No. 2" especially for paraffin work.

A number of paraffins of varying degrees of hardness may be obtained in the market, but the common and cheap form known as "parowax," used by housewives and found in grocery stores, will answer practically all of our purposes in northern temperate latitudes. Very likely some of the harder paraffins with higher melting point may be required for work

farther south. With the addition of a paper sack covering, however, for a few days, until grafts are well under way, parowax may suffice. Incidentally, the melter may be used for some kinds of glue or other material to be kept at a definite temperature when in fluid form.

Until recently propagators have preferred wood that is two or three years of age for grafting work, with hickories and walnuts in particular, because the last year's growth is apt to be pithy and more or less hollow. With the paraffin coating I have found that scions which were so hollow as to be spoken of as tin whistles by one of my men have grown quite as freely as scions cut from older wood. We have to use a greater degree of care in the sharpness of knives in order to avoid breaking down the pith or partitions (septa), which occur in many of the one-year-old scions. Scion grafting is now as economical as bud grafting because the short graft with only one bud will suffice if the paraffin method is employed. Formerly a longer scion was required in order that it might retain its "life" better. Bud grafting offered few advantages over scion grafting excepting in the greater economy of material and in the fact that bud grafting might be done in late summer when there was not the rush that formerly impelled us in the springtime. The matter of rush in the springtime has now been somewhat done away with by the methods described in this book, but bud grafting may be done later in summer or autumn than is possible with scion grafting as yet. Scion

grafting may be done from March to August in the latitude of New York, but bud grafting may be done well into September.

The shaping of scion grafts or bud grafts in the field consumes valuable time and I have experimented with watery solutions which would allow us to shape scions in the spare hours of evening in preparation for the following day's work, something which would serve as a harmless fluid medium in which the shaped grafts could be carried to the field in quantity. My original idea was to find something similar to what is called physiologic salt solution as employed in animal surgery. Animal tissues for grafting purposes may be kept in salt solution without appreciable change for several hours or days protected against microbic attack by the enzymes of their own uninjured cells. This principle could not be applied in its entirety to tree surgery for the reason that the salts, sugars, and organic acids in different species of trees vary so widely that no one constant isotonic solution can be made to fit all species. Professor C. C. Curtis, of Columbia University, suggested the employment of potassium chromate (not bi-chromate), beginning with a one-tenth of one per cent solution and working the other way until a strength was reached that would keep out microbes and at the same time not injure the plant cells of the cut surfaces of prepared grafts. I found that this practically would allow us to shape scions in the evening for use next day, keeping them immersed in the solution afterward, yet there appeared

to be enough injury to cells, probably caused by osmosis, to interfere with practical employment of this method on a large scale. Common water cannot be used for the purpose of keeping cut surfaces fresh, because there is osmotic exchange of salts between the cells of a plant and the water, which endangers the integrity of a cell very rapidly.

Professor Lewis Knudson, of Cornell University, to whom I put the question, made two suggestions. First, that the cut buds or scions be put into a two per cent solution of potassium permanganate. The basis for this idea was the fact that cuttings were sometimes allowed to remain in a two per cent solution before starting them in the usual way in the sand. Second, a solution of salts which would have a tendency to maintain a permeability of cells without alteration; the balanced solution consisting of

2.25 gm. $CaCl_2$
1.25 " NaCl
1.50 " KCl
I liter H_2O

When carrying both of these ideas into practice I chose the latter finally because of the osmosis question. Cut surfaces of the scions which had been shaped during the previous evening remained fresh looking during the entire following day and good catches were made with the grafts. I would not recommend longer immersion as yet but wish to suggest the idea for experimental development. A solu-

tion for keeping a lot of shaped grafts for several hours until they are ready for insertion includes another principle, the prevention of entrance of air into tissues of the prepared grafts.*

A cutting or so-called bud stick was formerly divided into segments three or four inches in length for grafting purposes as a rule. This long form of scion was not likely to dry out before union with the stock had taken place. Two or more buds were preferred for the long scion so that if one bud did not start another one might go into action. Paraffin coating modifies this idea. One bud to the scion is enough, provided that the bud has not been damaged. Cuttings from choice kinds of nut trees are too valuable to be wasted and the one bud scion introduces economy of material. The top end of a cutting is usually crowded with buds. Internodes are so short at that point that we may as well let the whole lot of buds go along with one or two of the end scions. Some nut tree grafters break off the largest top bud on the theory that it will demand too much nourishment from the stock before union has advanced far enough to keep up the pace. This is not necessary when paraffin coating is employed and we may watch with delight the glorious bursting forth of a large end bud with its whole handful of beautifully tinted scales and leaves. Scions with the almost invisible

* Just as the book is going to press the author has observed that Beaver hickory scions, shaped and ready for insertion, if placed in Knudson solution for two days or more and not trimmed again will start their buds into activity within three days after insertion but this is not desirable.

scale buds belonging to an annual ring have been chosen by some nut tree grafters on the theory that these would not start until union of stock and scion was well advanced. Scions of this sort may be used, the only objection being the need for persistent removal of natural shoots of the stock which will start off a long time in advance of tiny scale buds. Bud sticks for immediate grafting in summer should have all leaves cut off, leaving only the base of the petiole behind and as little of that as possible. For immediate grafting almost all of the herbaceous growth of the year should be cut away unless it is well lignified and pigmented. Herbaceous plants like the potato and tomato are readily grafted one upon the other. This being the case, we may eventually develop principles which will allow us to graft green growing shoots from one tree to another in the nut tree group. In experimental work with immediate grafting in summer the scions consisted chiefly of the previous year's wood together with some of the herbaceous wood of the year remaining attached, but so far the scions have expressed a preference for starting growth from latent buds in the old wood rather than for a continuance of growth from the herbaceous part of the scion. None of my grafting of the herbaceous growth of the year has succeeded as yet excepting with the most mature scions.

When a scion of chosen length is to be cut from the bud stick, shaping of the scion is next in order. It is to be trimmed full wedge shape for a cleft graft or modified wedge shape for a bark slot graft, the

modified wedge being shaped with a long cut on one side and a short one on the other side. (Figs. 3 and 4.) If the sun is shining brightly and the barometer is high when grafting is being done it is well to have a little pail of Knudson solution at hand into which the cut end of the scion is dipped occasionally while it is being shaped. This will prevent injury to cambium cells, which suffer almost instantly when they are exposed to bright light and dry air. The older horticulturists chose cloudy days or sunless parts of the day for their difficult grafting, but we may now work at high noon in sunshine if a dipping solution is carried along with the kit of tools.

The kind of knife that is used will have much to do with success in grafting. The knife should have a large handle for firm grasping and the blade should be inflexible and very sharp indeed. It must have an edge which will bring terror to the heart of a mother of boys. After using many kinds of grafting knives I finally settled down upon just one model after learning that Mr. J. F. Jones and other professional grafters had done the same thing. The knife has a wooden handle five inches in length and the blade a trifle less than three inches in length. It is made by Maher and Grosch for the wholesale trade and kept in stock with other grafting accessories by Mr. Jones for the retail trade. It is shown in the figures of grafting.

Shaping of each scion before cutting it away from the bud stick may be done to advantage if one is

careful not to injure buds that come within the grasp that is taken upon the bud stick. The grasp must be of the sort that belongs to handling eggs. If the scion is first cut away from the bud stick and shaped afterward, the insecure short hold may result in irregular knife cuts and failure of the graft in consequence. The cabinetmaker's training would be better than a course in law for a grafter.

A scion having been shaped in the right way by the right man with the right knife and cut from the right bud stick is ready for insertion into the stock. How shall it be put in? If the stock is of the same diameter as that of the scion the stock is split evenly in the middle and the scion inserted in an ordinary cleft graft way. (Fig. 5.)

If the stock is a little larger than the scion the cleft is made to one side of the middle so that width of cut still corresponds to width of scion. This is necessary in order to bring at least one cambium layer of stock and scion together as accurately and as nicely as possible. It is the cambium layers which contain cells for cementing union. If the cambium layer of scion comes into contact only with the wood or with the corky bark layer of the stock a man might better put the scion in his pocket and go to the movies instead of trying to be usefully occupied.

If the stock is very much larger than the scion in diameter, as in top-working the stubs of limbs or the trunk of a tree, we may apply one of the most important steps in technique that the author has developed in his attempts at advancing the subject of

grafting. For purposes of nomenclature it may be called "the bark slot method." (Figs. 6, 15, 24, 26.) By employing this method stocks of any large diameter may be grafted—even the stump of a great tree felled by saw. According to our textbooks grafting should not be attempted upon limbs of greater diameter than three inches. There is no limit to the diameter of a limb or trunk or stump of a tree which is to receive bark slot grafts. It may be three feet in diameter instead of three inches. There is one added responsibility and the diameter of the responsibility corresponds to that of the limb or trunk of the tree. We must keep the whole cut surface of the stock neatly covered with paraffin, or other protection, for several years until new growth has covered in the area that would otherwise be continually exposed to attacks from fungi and bacteria. Work of this sort would have no difficulties for the professional tree surgeon, but the amateur nut grower would be neglectful of his duties in the matter as a rule. For that reason the old textbook limit of three inches for the diameter of limbs to be grafted will still hold good for practical application.

The bark slot method is divided into two varieties, the distal graft and the proximal graft. The distal graft is employed for the distal ends or stubs of branches and the proximal graft is employed for any part of a limb or trunk of a tree that is proximally situated. The distal bark slot is made by holding the butt end of a scion alongside of the end of a limb and cutting through the bark of the limb on either

side of the scion. These two parallel lines are cut with a sharp knife if the bark of the stock is thin enough or with a carpenter's chisel and mallet for thick hard bark. The tongue of bark thus marked out with knife or chisel is then pried free and the scion slipped into the slot so made. The full length of the tongue of bark may then be folded back again to help hold the scion in its place or half the tongue of bark may be cut away and the remaining half replaced over the scion. (Figs. 7 and 11.)

The proximal bark slot is made in the same way excepting that we must cut an approach to the wood beneath the bark. (Figs. 12 and 13.) A transverse cut is first made through the bark, reaching down to the wood. A slanting longitudinal cut carried down to the transverse cut in the bark follows and the segment of bark thus freed is pried loose and removed. Parallel lines of the width of the scion are marked out from the transverse cut in the same way as when they are made from the end of a limb (Fig. 14). The scion is inserted into the slot so made. For bark slot grafting we choose the flattest part that is to be found on the stock. The reason is that the shaped scion has a flat cut and we wish to have it fit the stock wood as flatly as possible in order to avoid interstices into which sap might run and collect.

The so-called "slip bark method" employed by Mr. Riehl had this disadvantage of leaving large interstices. The slip bark method consisted in making a longitudinal slit in the bark of a stock and then slipping in a scion between bark and wood. When look-

ing at the distal end of a branch to be grafted we usually observe that some one part of the circumference of the branch is less rounded than the rest and the flatter part is to be chosen for the scion site. One may pick out in the same way a comparatively flat surface for a proximal graft.

When the scion has been inserted in a cleft graft it is bound in place with raffia or with twine in the usual way. Raffia is always preferable because it does not cut into the bark of the growing stock and it is usually burst asunder by the enlarging of the stock. If twine is used for binding material it will cut in and choke off growth unless the grafter keeps close watch and loosens the binding himself instead of allowing the tree to do it for him.

For bark slot grafting, on the other hand, very strong twine is preferable as a rule excepting with smaller limbs. Large limbs use up too much raffia and the strands are too short. The tongue of bark and the hard bark of these larger limbs will not allow twine to cut in deeply enough to do much choking. When the bark is very thick and hard no binding material of any sort is required for the bark slot graft because the tongue pried free with a lever will go back with such pressure upon the introduced scion that the latter is held snugly enough in place. For all of the bark slot grafting which requires binding material I have introduced the Spanish windlass method of fixation of the scion. The Spanish windlass which is used in surgery for controlling hemorrhage seemed to me to be applicable for fasten-

ing scions in place. It consists of a strong tarred or paraffined cord with ends tied in a firm knot but hanging loosely about the graft. A wooden skewer or any small twister is then inserted into the loop of cord and twisted about until the part of the cord about the stock wound is so snug that it holds the scion in place more firmly than it can be held by any sort of wrapping. In order to prevent the cord from cutting into the bark one or two shields of wood an inch in length may be interposed between cord and bark. The twister of the Spanish windlass is made fast with a staple driven into any convenient holding point on the stock in order to prevent the windlass from unwinding (Figs. 11 and 15). Galvanized staples may remain in place for a year or two without apparent injury to the stock. The whole scion and wound are covered with melted paraffin applied with a brush. (Fig. 8.) The windlass will sometimes remain in place for two seasons without change, holding the scion firmly in place all of that time and requiring no attention. The growing stock separates the two shields very much as it might separate two rocks on the ground at the base of a tree without injury to the tree. Along with this forcible separation of the shields there is automatically a tightening of the cord of the windlass. If we have cord that is strong enough and slippery enough, as with cord treated with paraffin, the tightening of the cord in the course of growing enlargement of the stock results in automatic unwinding of the cord nearest to the stock and compensating winding up

at the twister end. This automatic adjustment is very convenient if the windlass has been applied skillfully with the right sort of materials. It allows the graft to be left without attention for a year or more excepting for the bracing which should be given all large shoots. If the Spanish windlass is not applied skillfully with the right sort of cord the cord is burst asunder by the growing stock. This does no harm because the graft is by that time well under way. We simply lose the advantage of long time holding of the growing graft when the windlass cord is burst asunder. It is essential and difficult to make a clean smooth cut when shaping a large hard wood scion. A small block plane will do the trick very neatly. The scion is first cut roughly to shape with a knife and finishing touches are then given with the plane. When this has been done a large hard scion will fit as "right as a trivet." Just as these pages are going to press, Dr. Deming sends me Bulletin No. 76 from the University of Arizona Agricultural Experiment Station containing a description of grafting the Arizona walnut, *Juglans major*. Mr. C. R. Biederman, in addition to using the plane, employs a curved knife for making the face of the scion scarf slightly concave. He believes that swelling of the scion wood sometimes interferes with close approximation of cambium layers of scion and stock and that the concave cut avoids this obstacle to wound repair. I shall try the Biederman method experimentally, but his success gives basis for value in the plan.

If a scion is rested against a limb or any soft wood

when the plane is used lightly and rapidly no injury to the bark or the scion is to be feared.

The planed scion graft is adaptable for a bark slot graft and better yet for a splice graft. In the latter case the stock scarf is planed as well as that of the scion. Notwithstanding the need for extra care in bracing the shoot from a splice graft I find myself employing this graft more and more to the exclusion of the cleft graft, for small scions as well as for large ones. Large planed scions may be nailed in place.

Bud grafting differs from scion grafting in technique rather than in principles. When a bud stick has such large diameter that we cannot readily divide it up into scions a number of bud grafts may be obtained from it. These buds may be inserted into a stock by means of the old-fashioned T cut (Figs. 27 and 28) if we are dealing with thin barked species like the hazels. Thick barked species require a different treatment because the corky layer stands as a mechanical obstacle between cambium layers of graft and stock. (Figs. 24 and 26.) Paring down the edges of this corky layer requires too much time and nicety of work for practical purposes. Details of bud grafting are described at length in the textbooks on the subject. They cover the ground of nut tree grafting as well as that of ordinary fruit tree grafting so far as mechanical detail is concerned and I shall add in these notes only a few points which belong to our newer information. Mr. J. F. Jones has advanced our knowledge of the subject by a method which is best described in a

letter from him to the author dated July 19th, 1920, and edited slightly. The patch budder which he describes is an instrument of his own invention which removes a square of bark from the stock and a compensating square patch carrying a bud; the latter patch is inserted into the space from which the stock patch has been removed. (See Figs. 18 and 19.)

"The season for budding is on and I believe you use my patch budder in budding. I have found that cutting patches on the seedling stock a week to ten days ahead of budding, but not taking the stock patch off then, helps greatly in getting a stand of buds. I first thought of this three years ago and immediately put it into use. I noticed that the tree invariably took care of the patch of bark left after being marked out with the cutter. I figured that cutting the stock patch ahead a few days would allow the tree to callus over the cuts around it and that when this was done the patch containing the bud would be better and more promptly taken care of when put on. This seems to be the case, as I have tried it out now thoroughly; for this latitude at least it is a wonderful help. My first trial of it was in 1917. Two rows of Persian walnuts were budded on the same day (short rows). The row where the patch on the stock was cut at the time when buds were inserted gave two successes. The other row, which had the stock patches cut seven days previous but not removed at that time, gave us eighty-two successes. Seedlings were of the same age and same condition. Buds were of the

same lot and same variety and all put in by myself, the work being carefully done. I might say in reference to this experiment that previous to the cutting of the patches on the stock ahead of time we had had little success in budding the Persian walnut and had given up budding it. Later in the season in this latitude when the sap is not so active the patch should be cut ahead two weeks. I think probably three or four days in the lower south will be time enough, when the sap is very active, and probably a week ahead later in the season."

Parallel with this Jones method of bud grafting was one experience which I had with a shagbark hickory scion graft. While examining some hickory grafts about two weeks after they had been put in and which had not made a start, one of my men accidentally hit a scion with his elbow and knocked it out. He freshened the cut surface of the scion a bit with his jack-knife and stuck it back into the cleft in the stock from which it had been removed. A few days later this graft sprouted and grew while none of the others, which had been left undisturbed, made any sort of a start. I had intended to make use of this observation, but developed the method shortly afterward which made it unnecessary. In the case of the hickory accident quoted the principle involved apparently includes that which gives success in the Jones method of budding. The stock with greater vitality than the graft had put out an abundance of repair material. When the shaped end of the loosened scion had been freshened and re-

placed the reparative material of the stock already on hand accepted the fresh surface of the scion promptly.

In patch bud grafting we have become accustomed to removing a square of bark with the bud left in the middle of it. This situation for the bud is unnecessary and is doubtless due to our unconscious response to ideas of symmetry. If the bud is left close to one edge of the square of bark it allows us to sever the bud heart with a straight knife blade sharp knife neatly in the first step of prying off the patch. When prying off a patch with a bud situated in the middle of the patch the heart is often torn out of a large bud, or we injure the bark when trying to sever the bud heart with a straight knife blade passed under the curved bark. Cutting the patch in such a way that the bud is close to one edge of the patch allows us to avoid doing this damage to the large bud. There is only one objection. The patch cutter will not roll over a large bud situated close to the edge of a patch without breaking the bud off. We get around that difficulty by simply marking the bark with the cutter and then completing the work with an ordinary budding knife. This little trick requires a bit more of time for its performance, but one bud requiring three minutes of time for its removal and then living is better off than three buds removed in one minute and all dying. In the case of small buds the heart does not matter, but with large buds the accident leaves a hole in which sap may collect and ferment. Furthermore, some of the

important embryonic cells of the bud remain adherent to a bud heart that is torn away roughly. The old-fashioned chip bud graft was devised for saving time and avoiding injury to bud hearts (Figs. 21 and 26).

A method of bud grafting shown me by Mr. J. C. Rush, of Lancaster, Pennsylvania, has given good results in some seasons. The method of Mr. Rush consists in using a double bladed knife. The blades are far enough apart so that a ring of bark is cut part way around the stock and a ring of bark exactly the same width is marked upon the bud stick with these parallel knives. Having cut part way around the stock stick with the parallel knives a cross incision is made, joining these two circular cuts. The bark is peeled off part way around the stock but left in place until the bud stick patch has been inserted. Part of the loose ring of bark from the stock flap is then cut away, but enough is left to overlap one side of the inserted patch while the other side of the patch fits the stock bark snugly. (See Figs. 16 and 17.) The buds are then bound in place with raffia and the whole sealed with melted paraffin in my own work to date.

When sap is running so freely that it forces its way out from the paraffin coating we may leave one corner of the bud graft open for escape of sap and fasten a wad of absorbent cotton powdered full of borax over the site of the leak. Borax prevents fermentation of the sap, thus adding a feature of antiseptic surgery to our bud grafting work.

Before the days of employment of paraffin in grafting work it was best to protect scions from the sun and wind for a few days after they had been set. For that purpose nothing was better than cheap white paper sacks to be found at the grocer's. A hole for ventilation was torn in the top of the paper after the sack had been tied over a scion. When the buds were unfolding nicely the paper protection was removed. This detail may now be done away with in the latitude of New York. Wind cannot dry out a paraffined scion. The sun on a very hot day will soften the paraffin but not to the point of causing it to run away. A little stearic acid added to the parowax will harden it as it hardens candles. Stearic acid may be obtained at any drug store.

When there is a very vigorous growth of shoots after either cleft grafting or bark grafting it is very important to fasten laths or other bracing sticks to the stock and shoot so securely that the wind cannot blow these new shoots out. The single advantage of the cleft graft over the bark slot graft consists in having a firmer hold for the growing scion. I have known the better part of a season's grafting work to be ruined in two minutes of a wind squall before an approaching thunderstorm in August. Some of the new shoots were blown entirely out, others hung loosely from the stocks and the ones which remained in place had the granulation area at the junction with the stock seriously wrenched. For grafted saplings a light stick may be tied to the stock and to the growing shoot for bracing purposes, but for top-

worked trees cheap laths are better. They may be cut in half, or split, or used whole. Laths are easily nailed to the limbs or trunk of a tree with small galvanized nails, which are practically harmless. A growing shoot is then tied to the free part of the lath with one or more strands of cord. Tarred sisal cord is the best material that I have found for general tying purposes with everything from graft shoots to grapevines and roses. It is soft enough to avoid injury to the bark, strong enough to withstand severe strain, durable enough to last for two years of exposure to all of the kinds of weather that come along, and cheap enough to please a nut grower until his nut trees come into bearing. Tarred sisal cord may be purchased by the pound from any cordage dealer.

It is well to allow a lath to remain in place for two seasons for the support of the larger and heavier graft shoots. At the end of that time the support is removed and the galvanized nails withdrawn from the stock.

In order to hurry graft shoots into full growth it is desirable to rub off all natural sprouts from the stock as fast as they appear at first. With some kinds of trees, black walnuts and hazels in particular, this will have to be done two or three times a week in good growing weather. If it is not done the stock will quickly abandon nourishment of the graft in order to attend to Nature's first law, self-preservation. When dealing with small saplings all of the natural shoots may be kept down and nothing

but the graft allowed to grow after the graft is surely under way. With top-worked trees it is a different matter. When the shoots have started from a scion and have made excellent growth we may then allow some of the natural shoots of the tree to grow for the remainder of the first season. If this is not done the tree cannot store up enough nutriment for its root and stock system for the next year's growth. If a limited number of natural shoots are allowed to grow it prevents the new graft shoots from growing so large as to require elaborate bracing against gusts of wind before they are securely united. In the second year fewer of the natural shoots belonging to the stock need be left to grow and nourish the tree and in the third year they may be removed entirely, leaving none but the graft shoots to grow. The degree to which natural shoots of the stock tree are allowed to grow in connection with graft shoots is a matter requiring nice judgment, and introduces an element of art into this branch of horticulture. If all of the natural shoots are allowed to grow from the stock tree that has been trimmed back for top-working purposes practically every one of the grafts will be killed, apparently by repressive hormones from stock shoots. We must always remember that the propagation of trees is an art. Various artists will display their respective individualities in almost every step of the work. One man will have famous results where others fail.

Some trees, like the shagbark hickories, possess a limited number of latent buds. On that account

it is best not to remove natural shoots closely from a sapling stock before the graft shoot is actually under way, otherwise we may lose the stock. If a graft does not make a start from a sapling stock we need to have at least one natural shoot grow for bud grafting in the late summer or for scion grafting in the following year.

A new shoot from a graft will sometimes make a tremendous growth before enough sap can be supplied for repairing the wound and conducting the growth at the same time. These large shoots may even fall by their own weight without much wind unless strongly supported. To obviate this difficulty I pinch off the tops of some growing graft shoots when they have reached a length of a few inches. Natural shoots of the stock tree are then allowed to grow and meanwhile the scion growth is making firmer union with the stock. This obviates the necessity for very elaborate and extensive work in supporting all of the new grafts.

There is a tendency for a graft shoot to grow less rapidly than natural shoots, but the latter also are held in check by the tree to a certain extent. It may be that a natural shoot from an end bud or a shoot from a scion bud exerts what is called repressive influence upon growth, preferring merely to maintain a moderate degree of development until firm, woody union between shoot and stock is secure. We cannot go into the psychology of a tree, but it is a fact that lignification or woody union at the point of junction of the graft or of a natural shoot is not

very secure in most nut trees for the first year or two. If the stock were to send out great thrifty natural shoots in a hurry in order to make a large top for replacing the one that was cut away, these large heavy shoots might drop off by their own weight. The tree seems to be aware of that fact and may perhaps send repressive hormones to the root asking root enzymes not to hurry the top growth until the latter has become firmly united. In former years botanists held that what is called axial polarity or, in other words, the direction of sap movements in the long axis of the tree was due to the flow of materials for making shoots in the top part of the tree. They held that the flow of materials for making root was sent from the top down below the ground. The accumulation of these materials for building purposes in opposite ends of the tree was supposed to be responsible for the phenomena of polarity and regeneration. Loeb, has shown, however, that we must take into the problem a new factor, that of the formation of a special hormone in the end bud part of a shoot. This hormone exerts repressive influence upon the growth of other shoots below that point. It perhaps influences the degree of root development as well. The matter rests upon a chemical basis. The hard wooded hickories seem to be wiser than the chestnuts in their habit of repressing root action until the top is secure. The chestnuts send out enormous new growth before making top buds and coming to rest. These massive chestnut tops occasionally blow off in moderate

winds because of this lack of sufficient woody growth where graft and stock are joined. In the after-care of grafts, therefore, we need to remember that after-care of natural stock shoots enters into the problem also.

Eight Commandments for Successful Grafting

1. Choose closely allied species or varieties.
2. Bring cambium layers of stock and scion into accurate contact with each other.
3. Make close contact of cut surfaces with firm binding material or by the Spanish windlass method.
4. With a paint brush cover every part of the scion, buds and all, with melted paraffin which is spread also over the stock wound and the binding material.
5. Allow no natural shoots to start from the stock until the scion is under way with its own new shoot growing vigorously.
6. When scion shoots are several inches in length, allow some of the natural stock shoots to grow for the first year in top-worked trees.
7. Brace the growing scion shoots for two years.
8. Allow none of the natural sprouts from the stock to grow after the first year of grafting a sapling or after the third year in a top-worked tree.

CHAPTER III

HYBRIDS

ANIMAL breeders have been reported recently as occurring in the proportion of one tenth of one per cent of the number of people devoted to the subject of mechanical progress in this country. Plant breeders at the present time, while smaller in numbers than animal breeders, are so rapidly enlarging their field that they may pass the animal breeders and in a way approach the number of those engaged in mechanical progress. This at any rate might fairly belong to the history of civilization in connection with the development of food supplies. Experiments in nut culture have thus far been carried on largely by means of private capital or small government appropriations. Let us imagine that ten wealthy men in this country have relatives patiently waiting for them to pass away and leave money which will be spent to no good purpose. Any one of these men may make his name immortal by endowing nut culture at this time of its rapid expansion and need. Robert de Sorbonne was only one of many rich men in Europe in 1650. How many of these wealthy men in that period do we know about? He made his name im-

mortal by endowing an educational institution in Paris. A large endowment for nut propagation in connection with one of our universities would find on hand men already equipped with knowledge ready for going ahead rapidly with research work and practical application of their knowledge upon the subject.

The first course in nut culture in this country was established by Professor John Craig at Cornell some years ago. A number of students eagerly entered this promising field for life work. University funds, however, were not on hand for the development of the course and it was at once perceived that special endowment of large dimensions would be required.

We are now on the verge of a great development in hybridization, or crossing choice kinds of nut trees, and in determining upon which stocks the different kinds of selected nut trees may be grown to best advantage. Hybrids between varieties of nut trees occur frequently in Nature, but hybrids between species, on the other hand, occur but rarely. A number of these accidental hybrids have been discovered, however, and some of them are now being propagated. For the most part they do not represent the best quality of the best parent, but it is a noticeable fact that the bitterness of kinds with bitter pellicle appears to be a recessive character and disappears usually from hybrids between species in which one parent has a bitter nut. Unfortunately, the finer extractives which give quality to the nut of the better parent are prone to disappear also. This

is in line with our experience in the mixing of characters along Mendelian lines. Given a sufficient number of hybrids and we shall have here and there one with spectacular characteristics of special value to be handed down by grafting upon other stocks.

Now that horticulturists of the present moment are turning so freely toward the idea of producing qualities of hybrids artificially the next generation will see nuts which were not dreamed of in the days when I was a boy. The crossing of nut trees is not difficult work. It is pretty work, suitable for any one with a speculative turn of mind who likes to do constructive things—like the making of new kinds of trees. We simply remove the male flowers from branches carrying female flowers before the male flowers have begun to shed their pollen. The female flowers are then covered with oiled paper bags tied over them for protection, and when the danger from self-pollination is passed we take off the bags and add a little pollen, which we have kept for the purpose—pollen from some tree bearing remarkably valuable nuts.

Nuts resulting from this cross pollination when planted give us new varieties of nut trees which never have been seen before by anybody and that is so interesting that very many people will probably take up hybridization as an outdoor sport. Some of the hybrid trees will have remarkable timber value, and others remarkable nut value. Some of the hybrids will bear very early in their history and others very late. If one is impatient to determine at

once which ones are to be valuable he may hurry the process by grafting a large number of cuttings from young hybrid seedlings into the tops of larger trees which are already bearing but cut back for top-working. It is possible to put one hundred or more seedlings in the top of some one stock tree at one time, labeling each one, and in this way avoid several years of waiting to see what is coming out of a lot of young seedling hybrids. The latter, with only part of the top cut off, keep right on growing, so nothing is lost.

The flowering time of different trees varies considerably. For that reason it is well to have varieties of species which blossom at the same time within easy hailing distance of each other so that they may exchange the gold pieces of their pollen. Many of the Persian walnuts, like many other trees which have been long under cultivation are not self-pollinating or if self-pollinating do not respond with enthusiasm to close inbreeding. They require some neighboring tree to furnish the most stimulating pollen. This is true also of some of our best pecans. With them it can hardly be a matter of long cultivation but rather a fact indicating that a very fine variety, fine from man's point of view, is not in the list of Nature's favorites. Nature is indifferent about continuing the propagation of kinds of which she does not fully approve. There is another biologic law involved. We find a parallel with animals. The American bison which lived in large herds seemed to require crossing over a large number for success-

ful breeding. When small groups were selected by ranchmen for propagation it was found necessary to exchange breeding animals with men who had other small herds. This seems to be a parallel case with the hazels, which bear heavily when there is extensive cross pollination. A single hazel bush set out at a distance from its friends becomes so lonesome that it is not much interested in continuing its kind. We must cater to the sociability of the trees and plant individuals of several varieties within hailing distance of each other.

Hybrids belong to three chief groups. The heterodynamic hybrids are those which represent one or other parent prominently, and this sometimes occurs to such an extent that we may not know whether a tree is a hybrid or not until it comes into bearing. I had one series of trees resulting from the placing of American chestnut pollen upon pistillate chinkapin flowers which showed chinkapin characteristics so distinctly in progeny that I believed them to be parthenogens (one parent only) and not real hybrids. A number of them were set out on a side hill and practically forgotten, but when they came into bearing the fruit showed distinctly that these young trees were hybrids. At the present time I have also a large number of what appear to be butternut parthenogens, yet some of them may prove to be hybrids when they come into bearing. Homodynamic hybrids are those in which we have an equal or nearly equal combination of the characteristics of both parents, although with homodynamic hybrids attributes of

one parent may remain latent as with heterodynamic hybrids, and these latent characteristics may appear in later progeny. The term derivative hybrids is applied to the progeny of hybrids crossed with hybrids. Hybrids of any sort often show new peculiarities which are not derived from either parent. This may be exhibited in the time of bearing or the kind of bearing, or in rapidity of growth, for example.

In cross pollination we have depended up to the present time upon the stimulus of enzymes contained in the flowers for promoting the union of gametes (two sex elements joined to make a zygote or germ). This, however, is a chemical process. If parthenogens in lower animal life may be made by artificial stimuli it is possible that the hybridizers of to-morrow may find artificial stimuli which will encourage formation of a zygote between gametes of species which at the present time do not unite to form hybrids. One feels that to-day we are merely upon the verge of horticultural knowledge which will be revealed to the plant physiologists and horticulturists of to-morrow.

Nature's purpose of sex union is apparently to combine the characteristics of both parents, and this tendency is so well marked that some species of plants have actually protective apparatus to prevent access of their own pollen to the female flowers of the same plant. Remarkable nut trees, like other remarkable fruit trees, represent variants from the mean type and, following organic law in this respect,

will then present peculiarities in sexuality and we shall have to allow for cross pollination requirements in setting out nut tree orchards. Many varieties of nut trees, like varieties of cherry trees, are not self-pollinators.

In a book published in Berlin in 1793, Christian Konrad Sprengel first called attention to the fact that the maturing of the stamens of the flower and the pistils of the flower commonly occurred at different times. He deduced the conclusion, which is now accepted by many authorities as a right one, that Nature did not wish to have flowers fertilized by their own pollen. On the other hand, eucalyptus trees from the newer continent of Australia do not raise the protecting lid from the flower until secure self-pollination has occurred. This may leave us in some doubt as to whether Nature has changed her mind in recent times in relation to cross pollination of older trees or if her laws are still immutable and man is a cheap lawyer.

Nature to-day, apparently, favors the origin of new organic forms and apparently wishes to have crossing occur only between varieties of a species and not between species. We observe in hybridizing work that the pistillate flowers of a plant accept the pollen from another plant of the same variety more readily than they accept the pollen of another species, and there is some question if they would accept the pollen of another species at all unless the pistillate flowers are forced by accident or man's intention to

accept pollen which is furnished under unusual conditions.

Plant breeding was introduced at the beginning of the nineteenth century by Andrew Knight, William Herbert and Carl Friedrich von Gaertner, but their work was not appreciated, and in fact was overlooked, until Mendel's papers were given attention nearly a century later. Scientific plant breeding began with full force in the beginning of the twentieth century and is now proceeding with great rapidity.

The method of crossing flowers is simple enough but one must guard against accidents. Male flowers are to be plucked from a branch carrying female flowers and the branch is then covered with a paper bag before the male flowers have begun to shed their pollen on that particular tree or before pollen has been blown from neighboring trees of allied species and varieties. The reason for this is that pollen is carried through the air for a considerable distance by the wind. If any flowers of trees of allied species or varieties in the vicinity are shedding pollen some of this pollen may already have alighted upon female flowers which we wish to hybridize. For protection purposes ordinary paper bags of the sort to be purchased at the grocery store will suffice, but some hybridizers prefer to oil these bags because the oiled paper allows more light to enter and lessens the possibility of any minute pollen grains making their way through imperceptible cracks in the bag. For most nut trees paper bags of ten, fifteen, and

twenty-pound sizes are preferable. The male flowers having been plucked from the branch the open bag is carried over the end of the branch and tied so securely that the wind will not open it. I found a wren's nest with two eggs in one of my bags. Pollen would have required less of an opening.

One intermediate step is extremely important. At the time when we do our hybridizing of nut trees the troops of warblers are on their way northward, searching every opening leaf and bud and destroying insects which are hatching. When bags are placed over the ends of branches insects will very frequently increase to such an extent under protection of the bag as to entirely destroy all of the leaves or even the flowers of the branch. No more startling object lesson of the value of birds in relation to our forest trees can be obtained. In order to avoid this mishap in question it is important to dust the flowers and the tender young leaves with Persian insect powder before adjusting the bag.

The bag is allowed to remain in place until all of the male flowers of that tree have shed their pollen. The bag is then removed, preferably at a time when no wind is blowing and there is little chance of pollen from a distance being borne to the flowers in the few seconds required for hybridizing. Pollen of the species which we wish to add is then placed on the female flowers. Pollen grains are round and not easily handled with a brush. They roll out of it like so many shot. I find the best implement to be a rye straw cut in form to make a little shovel. The

hollow end of the straw may be plugged with a bit of cotton so that the shovel end which protrudes will carry only a few grains at a time to be dumped on the female flower. The bag is again tied over the branch and allowed to remain for several days longer before being finally removed. In order to mark any particular limb it is well to fasten a wooden tag with a copper wire about the branch. If twine is used red squirrels are likely to cut it as a matter of pure mischief in all probability. I would not pretend to follow the ideas of the red squirrel further than to say that it does many things in the spirit in which I did them as a boy.

Pollen is secured by shaking the male flowers when in full bloom on a sheet of paper very gently and then rolling the collected pollen into a paper box, where it may be kept for some days. The paper box containing the pollen should be kept in a cool place or in cold storage and there should be a considerable degree of moisture in the air where the box is kept, although the pollen should not be allowed to become really moist. If it is allowed to dry it soon loses viability and if kept too moist it is quickly attacked by fungi and bacteria. Some kinds of pollen remain potent for a few days only while others retain viability for a couple of weeks.

Where the trees which are to furnish pollen have a blossoming time far from that of the trees which are to receive pollen I have secured pollen from the northern and southern limits of the range of the species desired. Thus, for experimental work in

placing pollen of the chestnut and of the beech upon the oaks which blossom in the first week in May at Stamford I have secured chestnut pollen from Professor H. H. Hume, of Glent Saint Mary, Florida, and beech pollen from Dr. H. N. Conser, Orono, Maine. Chestnut trees and beech trees in these widely distant localities ripen their blossoms at the time when the oak trees in Stamford are in bloom. By securing correspondents in various parts of the country one may obtain pollen at a time when it is wanted. Pollen is best sent by mail in wooden pill boxes, which are not easily crushed and which at the same time allow the pollen to breathe. We must remember that pollen grains are all alive and active and need to breathe air, although a very little air will suffice. If pollen is sent in glass bottles, corked, it is quickly smothered.

When we are handling several sorts of pollen at the same time we must be careful that the wind does not mix up the different kinds. On one occasion I distributed open paper boxes of pollen about several rooms of the farmhouse so they would be safely far apart. A neat housekeeper, finding these boxes in different rooms, gathered up such things of a kind and put them nicely on one shelf in a closet with an open window where oreads brought spring zephyrs as allies to defeat my nefarious plans aimed at their wards.

We must keep the female flowers covered until the possibility of a tree catching pollen which it prefers is passed. The Japanese walnut apparently

prefers the pollen of our butternut to its own pollen at times. A number of instances have now been recorded in which the progeny from nuts of the Japanese walnut gave butternut hybrids, although both trees were blossoming at the same time.

One way for retarding the development of male flowers until they are wanted for pollinizing purposes consists in cutting branches carrying immature catkins and putting them in cold storage. I have retarded the development of hazel flowers for a fortnight by placing them beneath the sawdust near the ice in the ice house when wishing to use American hazel pollen for European or Asiatic species, which blossomed considerably later. When the time comes for allowing male catkins to develop, the branches are placed in jars of water in a sunny room with closed windows. These blossoms will shed pollen in a few days.

The plant breeder cannot always be sure that he has made good hybrids when nuts develop upon branches, the female flowers of which have been artificially pollinized. Apparently the pollen grain excites some cell of the female flower into development at times without making fusion. In that case we get a parthenogen, a plant with but one parent, the mother.

Only a small proportion of hybrids present characteristics which are particularly valuable. When the chestnut blight appeared in Connecticut I set out with the idea of finding kinds of chestnuts which would resist the blight and got together from dif-

ferent parts of the world twenty-six varieties and species of chestnuts. Out of that lot I found four kinds which were distinctly resistant. *Castanea mollissima* from the northeastern Orient, our common American chinkapins, *Castanea pumila* and its variety *arboriformis,* and also the alderleaf chestnut, *Castanea alnifolia.* The first of these, the Chinese chestnut, had a large and rather coarse nut while the other three have a quite small nut of very high quality. Crosses were made with the idea of combining the quality of a chinkapin with the size of a Chinese chestnut. Crosses were also made between the blight-resisting kinds and a kind which blights readily, the American sweet chestnut. Hybrids with the Japanese chestnut, sometimes bearing very beautiful nuts, seemed to retain the coarseness of the Japanese nut. Of crosses between the chinkapin and the American sweet chestnut, those parents which are more like the chinkapin parent in type seemed to retain the blight resistance of that parent, while those which assumed the type of the American chestnut appeared to lack blight resistance. A few of these chinkapin-like hybrids have proven to be valuable for the size and quality of the nut, for precocity in bearing, and for blight resistance. Dr. Walter Van Fleet, whose experimental work with chestnuts is very extensive, finds that at Washington the Japanese chestnuts are all more resistant than the Chinese ones. This may be due to the carrying of spores by some local borer, choosing one kind of tree. Hybrids

which make remarkable timber growth are seldom prolific in bearing, and vice versa.

When the little nuts have begun to develop after cross pollinization and the branches have been labeled it will sometimes be necessary to cover nuts with wire gauze in order to prevent depredations made by squirrels and white-footed mice. Paper bags will not suffice.

Mosquito netting about nuts does not frighten away squirrels, although it is desirable to cover ripening hybridized nuts with bags or mosquito netting in order to prevent them from falling to the ground during the night or in the course of storms when we may not be watching at the time for collecting them. Even when wire gauze is used squirrels will sometimes cut off the branch allowing gauze and all to fall to the ground.

The white-footed mouse is nearly as destructive as the squirrel, particularly in relation to thin-shelled nuts. I had a large number of hybrid acorns and chestnuts covered with paper bags in one year when the ripening season approached and imagined these nuts to be all safe, but later discovered a very small hole in each bag close to a limb. In the bag a handful of shells showed where the white-footed mouse had eaten the nuts at his leisure, safe from his enemies, the owls. White-footed mice climb trees nearly as well as squirrels do—a fact which is not generally known because of the nocturnal habits of this species.

CHAPTER IV

ORCHARD CARE—INTERCROPPING—PRUNING—PARASITES

TREES for nut bearing and trees for timber require separate treatment. They are to be set far apart or near together according to our wish to obtain fruit or timber, one or the other, not both from the same tree. Trees of any sort when growing closely together have to keep an eye on each other; neighbors will run off with the food and water belonging to any one tree that does not take care to keep ahead in growth. A tree standing alone by itself and not obliged to be alert for self-protection is not fully occupied with getting what the world owes it. There is time for breeding, to give more generously of itself to the cause of the species. When we set young nut trees far apart in anticipation of what they will be to-morrow in the mind's eye a great deal of idle land lies in between them. The question of intercropping for profitable occupation of ground in the spaces between young nut trees may be considered. Trees like the Persian walnut, pecan, and black walnut should really not be set less than one hundred feet apart. Adult trees of

these species may have a spread of nearly that range while they are still in vigorous bearing, and we know that the roots of nut trees do much of their feeding from hunting grounds far outside of the circle of branches. A Persian walnut tree on the Milbank property at Greenwich, Connecticut, only fifty years of age at the present writing, has a spread of seventy feet, and more to go. The black walnut and pecan may even exceed that spread at the same age. We are all young at fifty. Shagbarks, while having less extensive range of branch, may have a remarkably ambitious lot of roots which go in search of water and nitrogen a long way from home. On that account a good deal of care must be exercised when planning to put in fillers for the purpose of intercropping.

The economics of the question would find parallel in a community in which people are to live upon the products of the surrounding country so long as such products are free for all. After that time the people of the community would depend upon stealing from each other. It is good business for the nut orchardist to arrange his village of trees in such a way that the inhabitants of the village shall not be obliged to steal from each other in order to be prosperous.

In the southern states various annual plants are used for intercropping young pecan plantations, but the author's preference would be for hazels and hybrid chestnuts in order to consistently hold fast to the nut tree idea. These small pawns may be cut

out as rapidly as they are encroached upon by the monarchs. The pang of cutting out a small tree is less in degree than the misery going with the felling of trees of larger kinds which have been set too near together. The idea of removing every alternate grafted nut tree at a time when the whole orchard is gloriously smart is something belonging to the horrors of history. On the other hand, a series of small annual pangs like the removal of hazels is easily borne. One of the author's friends whose trees had been planted too near together remarked that he had tried to bring himself to the point of cutting out every alternate one. His courage had failed him for six years in succession. Being an orchardist, he was a good man with no enemies who could be called in to do the cutting. The only hope left was that he himself might die soon.

Blackberry, raspberry, currant, and gooseberry bushes are sometimes employed for intercropping purposes, but if one were to have twenty acres of that sort of planting he would suddenly find himself possessed of a whole lot of berries. When large acreage has been devoted to nut trees the choice for intercrops will probably turn toward the idea of employing species of nut trees which do not grow large or else of putting the spare ground into leguminous plants which collect nitrogen from the air. Their roots enrich the ground, and if the tops are plowed under from time to time poor soil may be made fertile without the addition of manure or of chemicals. Some of the nitrogen collectors, like

alfalfa or sweet clover, have such long roots that they pump water out of the soil from a depth far below that reached by roots of young nut trees. On that account peanuts, soy beans, and various short root clovers are preferable. Even these should not be grown too near to the nut trees. We must remember that their roots are constantly drawing toward themselves all of the water and nourishment that will respond to their invitation to come. Profitable bearing of the nut orchard will be delayed in proportion as we wish to make other things profitable when grown upon the same land. It is a question of relative values. If one has land enough it is better to plan to get nothing but nuts from the nut orchard and to hurry the trees into profitable bearing.

Although some trees when grafted upon nursery stock will begin to bear in two or three years we have to estimate the time of really prolific bearing very much as it would be estimated for apple trees. It is not always best to allow nut trees to bear when young, and if all of the nuts are removed for the first three or four years it will allow the tree to put that much extra energy into growth. Before the chestnut blight came a Pennsylvania chestnut grower told me that he made a net profit of thirty thousand dollars in one year on grafted chestnuts and no tree in his orchard was over fourteen years of age, most of them much younger. Many of the trees in this orchard, however, were grafted upon shoots from cut-over chestnut stumps with old roots. There

were three hundred acres in the orchard. This nut grower's profit represented original investment that would be considerably less than the average expense of preparation for a young man in one of the learned professions, and there are few men in learned professions who can count upon an income of thirty thousand dollars a year.

It is commonly a matter of witticism to remark that a man plants nut trees for his grandchildren. As a matter of fact some of the Oriental chestnuts will bear a burr in the second year, even as seedlings. Many of the hybrid chestnut seedlings will bear in the second or third year and a number of different varieties and species of grafted walnuts and hickories will begin to bear from the second to the fourth year after they have been transplanted. Old trees that have been top-worked and already have a well established root system will sometimes allow the varieties which have been grafted upon them to bear freely two years after the top-working. Much depends upon the species. A hybrid chestnut scion which was grafted upon a Chinese chestnut in the middle of May bore two burrs with nuts that were picked in the middle of September of the same year. One of the hickories, the Hales, on the other hand, has been known to require fifteen years after grafting to come into bearing. As a rule, however, we may compare nut trees pretty closely with apple trees. The Yellow Transparent apple commonly comes into bearing in the second year after it is transplanted, while the Northern Spy may not bear until ten or

twelve years later. The matter of bearing, however, depends upon other factors than that of variety or species. If the grafting material is taken from bearing wood it will produce nuts much more quickly than if it is taken from water sprouts or stump sprouts, acting very much like apple grafting material in this regard. A nut tree which might not bear under ordinary wild conditions until it was twenty years of age may at one year of age furnish scions for grafting upon stocks three years of age, and these grafts may then fruit in the second year afterward. A difference between five and twenty years, let us say, brought about by grafting and cultivation.

On the whole, nut orchards are to be spoken of like apple orchards in so far as the time of profitable bearing is concerned. The advantage of the nut orchard over the apple orchard lies in the greater average age to which nut trees grow, steadier market demand for the product, less need for hurry in collecting and marketing the crop, greater food value of the crop and larger net income to be derived from the product of the nut orchard.

Nut trees in general will stand more neglect than would be tolerated by fruit trees which have been under cultivation for centuries. On the other hand, all nut trees will purr when petted. One of the little scrub hickories standing a bit apart from other scrubs was accidentally included among grafted hickories which were being cultivated in one of my lots. This went on for three or four years before the mistake was observed. The little wild hickory

by that time had towered far above its neglected mates and its wealth of dark green foliage was something worth stopping to look at even when one was in a hurry.

Ideal cultivation for most of the nut trees would undoubtedly be clean cultivation. That is expensive, but always necessary for young trees, at least for a limited area about each one. Next in order comes sod culture for the older trees with a cleared space kept hoed for a short distance around each trunk. If grass and weeds beneath the tree are cut several times during the season and allowed to remain and decompose upon the surface they furnish food for the roots underneath. One may add lime or other fertilizers beside bringing more trash and weed tops to be distributed over the ground beneath the sod culture trees. This method of cultivation may be applied with a high degree of success on rocky or stony lands, and is to be given serious consideration for all sorts of ground. Statistics upon the subject have been collected in relation to apple trees, showing that sod culture properly conducted has a high value. It may not always be properly conducted. A somewhat slack farmer who was looking at my sod culture trees said that he always treated his apple trees in that way excepting that he kept the ground free from such a lot of trash beneath the trees. That was the very point. The trash had been put there purposely. My visitor was up to date on sod culture very much as he perhaps was on the subject of phonetic spelling. We cannot apply sod

culture and plowing of the land alternately. It must be one thing or the other. The feeding roots of trees have a tendency to creep toward the surface of the ground, and these are seriously injured when the ground is plowed after a year or two of sod. Under conditions of annual plowing, on the other hand, when cover crops are used the feeding roots of trees remain safely deep down out of the way of harm.

Fertilizers for old and young nut trees belong in the class with fertilizers for other fruit trees. The same rules apply to both so closely that little need be said beyond impressing the point that nitrogen, potash and phosphorus in sufficient quantities are essential for the growth and bearing of nut trees as of other fruit trees. Where the soil is deficient in any one of these substances information may be obtained from the nearest State Agricultural Experiment Station or Agricultural College in regard to the best way for balancing the ration of the trees in that particular locality. Authorities at such institutions who stand ready to give free advice at any time say that the people do not as yet know how to make use of their opportunities for getting information.

Nut trees for the most part require very little pruning, yet there is always something to be done with cutting out superfluous branches, dead sticks, or unsymmetrical limbs. Mr. Jones gave me a saw which he uses for nut tree work and said that I would find it a handy one to use on Sunday morn-

ings when taking a stroll through the orchard with nothing else to do. As a matter of fact, I found that with this in hand on Sunday morning there was so much to be done that I couldn't get back to the house on time for church.

Pruning of nut trees for shaping purposes is not required to such an extent as it is for other fruit trees which have been for a longer time subjected to the conditions of cultivation and have acquired bad habits. The branches of nut trees are for the most part arranged by Nature for the best securing of light and support of weight. Whatever pruning of live limbs really needs to be done had best be done a month or two before the buds start. A good deal of active chemistry suitable for repair work is going on in a tree as soon as the frost is out of the ground. The tree begins to look toward the dawn of a new season when peep frogs send their merry jingles from the marsh, and the newly arrived crows sag along through the soft morning mists. The reddening of dogwood branches and the goldening of willows indicate that all trees are awakening a long time before they would risk putting out buds. Then is the best time for pruning if we wish to get the best repair. When limbs are cut in the summer time a host of spores of fungi are active and alert for opportunity to attack a tree wound. In the winter the tree, half asleep, may not callus a cut sufficiently. It is a fact that a covering of all tree wounds with melted paraffin or other good protective agent will guard against microbic

enemies, but the busy orchardist is not always more particular about attending to that detail than he is in the matter of his own health.

Trees, like men and other animals, almost always die from the effects of poison before their time (excepting for accidents and sudden violence). The poison consists of by-products of microbes which are too small to give the fright that would be caused by the sight of a rattlesnake. Microbes are really more potent than rattlesnakes, even though slower in action. Until that fact becomes generally known good orchardists and their trees will both suffer from preventable illness and premature death. Parasites, which are invisible excepting with the aid of a microscope, will continue to be the worst enemies of trees and men for many moons. From the microbe we go to the cow as a pest next in order. Cattle have a way of getting through the fence on days when we are not there to take notes and make remarks. Young nut trees are very seriously damaged when cattle discover the tempting shoots with tender leaves held out to them on a stick at just the right height for convenient browsing. The tops of all young nut trees of temperate regions excepting the walnuts are eaten by cattle which do further damage by rubbing their heads against trees and breaking branches. Even the walnuts are injured in this way, and I had one field of young grafted walnuts almost all ruined last summer in the course of a few hours by a herd of cows which got through the fence. Woodchucks are particularly injurious to young trees in the early

spring. Instead of gnawing like other rodents they tear off long strips of bark in such a way that bridge grafting for purposes of repair is next to impossible. The steel trap and rifle do pretty well for woodchucks. A combination of boy, dog, and stone wall is also helpful at times. Rabbits may be kept away from young nut trees by wrapping the trunk of each tree with galvanized netting in such a way that the netting will unfold as the tree grows. This material may be left in place for several years and it guards against the attacks of field mice also in a way. Field mice, however, do a good deal of girdling of trunks and of roots below the surface of the ground. A good many of these little pests may be killed with grain soaked in a weak solution of strychnine to which enough saccharin has been added to modify the bitterness of the strychnine. If poisoned grain is placed in a small drain tile hidden under a heap of mulch by the side of each tree the mice will find it and the tile will prevent birds from getting into trouble. Mice will not gnaw the trunks of young trees which have been painted or whitewashed. Tar must not be used. It often kills trees with tender bark. I did not know that white-footed mice worked beneath the ground like field mice and pine mice until one night when four of them were caught in a cage trap set below the surface of the ground in a pit which was covered with a board.

The walnut weevil, *Conotrachelus juglandis,* presents a curious instance of change of natural habit in the presence of exotic trees. Originally this

species made its home chiefly in the involucre of the butternut. With the introduction of the Persian and Japanese walnuts the weevil found something more to its taste and laid eggs in the herbaceous growth of these trees so freely as to completely ruin young growing orchards unless the matter were given attention. At my suggestion a study of the subject was made by Dr. W. E. Britton, of the Connecticut Agricultural Experiment Station, who published a pamphlet containing a description of the natural history of the species and giving rules for successful control of the pest. The adult weevil begins to eat tender bark of new shoots of the year after they have put out a short distance. After a few days of feeding the female lays eggs in slots which she cuts in the bark. The larva makes its way to the central pith of the shoot and eats so ravenously as to cause wilting of the stem and leaves. In badly infested young trees the entire top may be killed. At Stamford after the walnut weevil had acquired the habit of burrowing in Japanese and Persian walnut shoots it apparently then increased its range and appeared not infrequently in herbaceous shoots of the butternut and bitternut. It is possible that the weevil did this before but no one seems to have called attention to the fact, and I had not observed it until the weevil had been at work with the exotic species for two or three years. Happily we have a means for destroying the walnut weevil rather easily because the little beetles have the habit of feeding for some days before laying their eggs. If ten-

der shoots are sprayed with arsenate of lead in the proportion of about one pound of the paste to ten gallons of water the beetles are killed. Two sprayings are necessary, as shown by Dr. Britton, because of there being apparently two broods of weevils, the second brood following about three weeks after the first. Perhaps it is not proper to speak of broods in the sense in which we refer to the subject in connection with the larvæ of butterflies and moths. The delayed group apparently represents a provision of nature against an accident of weather or other condition injurious to the first group. Nature makes provision against loss of her dear weevils in such a way that some do not emerge from the ground at all during the first season but remain over until the second year, very much as codling moths are preserved against accidents which would distress the entomologist. Japanese walnuts are so tempting to the walnut weevil that when new shoots start from stocks which have been cut back for grafting purposes the weevil may lay eggs as late as August, in order to prevent such good material from going to waste from the weevil's point of view. Some of the saw flies are very destructive to European hazels. The saw-fly larvæ may be recognized by their habit of working in a row like a column of soldiers on the margin of a leaf and by the habit of erecting their hinder parts at a sharp angle to the rest of the body when they are disturbed. They are easily destroyed with a spray of arsenate of lead, which need not be

stronger than one-half pound of the paste to ten gallons of water.

The walnut caterpillar, *Delana integerrina,* appears late in summer. The caterpillars with somewhat inky skin and white hairs work together in large colonies upon the black walnut, butternut and hickories. Sometimes when a small tree is attacked the leaves are removed entirely and sometimes so late in the season that the new growth following their raids is winter-killed. In the north there is only one brood, but in the southern states there are two. Ordinary spraying with lead arsenate, three pounds to fifty gallons of water, will destroy these caterpillars. The species has one weak point which allows of ready attack during the evening or in rainy weather. The walnut caterpillar colony has the habit of descending to some one limb and there resting in a great mass in a loosely spun hammock weighing several pounds, which may be removed by hand.

A husk worm, larva of a fly not yet identified, has proven injurious to the nuts of the black walnut and the Persian and the Japanese walnut. The involucre turns dark before the nut is ripened and the immature nut then falls to the ground. On breaking open the involucre a large number of small white larvæ are found to be at work. This pest will prove to be serious unless we can learn the habits of the species and find some weak points at which it may be attacked.

A number of species of the genus *Acrobasis* at-

tack the buds of walnuts and hickories in the very early springtime and in later broods. The early brood will tunnel into the buds and altogether destroy or injure them severely before they are fairly well under way. Large fruiting buds are the ones which suffer the greatest damage. There are several broods during the season, and the later broods of some of the species spin a thin web which protects them against bird enemies. In this small book no attempt will be made to refer to other genera of bud worms which attack nut trees. The practical point relates to the fact that arsenate of lead spraying will destroy all of the bud worms. In this connection it is necessary to spray the buds of the walnuts and hickories at the very first swelling of the bud before the bud scales have expanded, whenever we find that any one colony of bud worms has become established in a locality.

The fall web worm, *Hyphenatria cunea,* which attacks a very large range of kinds of trees indiscriminately, includes the nut trees in its ravages. The caterpillars make nests near the ends of branches by drawing leaves together with their webs. Sometimes the nest may be found as early as June, but the largest number appear in July and August. The worms of this species work within the protection of leaves that have been drawn together and covered with a web. Spraying is not so effective as with most other species but the clusters of leaves that have been bound together are readily recognized and easily clipped off and burned.

Chestnuts, hazels, hickories, and acorns are attacked by larvæ of a number of species of weevils belonging to the genus *Balaninus*. All of the chestnuts, including the chinkapins, sometimes become so much infested in a locality that few sound nuts are to be found. The species attacking the shagbark hickory are inclined to make large colonies in connection with some one tree, although other trees in the vicinity seem to offer just as good eating. They have a tendency to choose some annually bearing tree with thin-shelled nuts. When this is the case we may dispose of the colony by collecting every single nut, perfect and imperfect, that falls from the tree in any one season, and fumigating all with carbon disulphide. The nuts to be so treated must be put into an air-tight receptacle like a metal ash can and two ounces of carbon di-sulphide for each bushel of nuts is placed in a shallow dish in the receptacle and the cover then snugly closed. At the end of twenty-four hours the cover may be removed and one may find by cracking a few nuts if the weevils have been killed. This treatment does not injure the germs of nuts which are to be used for planting. Chestnuts which are infested may be treated in the same way, particularly chestnuts which are to be used for planting purposes. For eating purposes one does not relish the idea of finding even a very small weevil larva in a nut that is to be eaten—even when the larva has lost all hope.

The hickory shotgun borer, *Scolytus quadrispinosus,* is called the shotgun borer because the bark

which has been attacked looks very much as though it had received a charge of number six shot. The adult beetles eat holes in the axils of the leaf stems during May or June, the leaves falling a month or two later. The female then lays a double row of eggs in the bark of the trunk of the hickory tree and the larvæ tunnel at right angles from this point, each making its special gallery. When the larvæ are sufficient in number the branch or even the main trunk is gradually girdled and dies. In some localities in the east this species has been very destructive to hickory trees, but on my own property it has attacked only one species, the pignut, so far as I have observed. A small group of trees will be attacked and then the natural enemies apparently catch up and restore the balance of nature, trees surrounding the infested group escaping. There is no practical way as yet known for controlling the shotgun borer of hickory trees. Dead or dying trees may be cut before the beetles come out in May and the wood may be promptly burned.

The painted hickory borer, *Cyllene pictus,* is perhaps the commonest one of a number of large borers which attack the trunk of a hickory tree. It also attacks the walnut occasionally. Sometimes borers of several species attacking the wood of the trunk of a hickory do a considerable amount of damage and the best way for controlling them in my experience is to clear away the "sawdust excrement" from the mouth of the hole and throw in a few drops of di-sulphide of carbon or gasoline, finally putting a

bit of putty or soap in place to close the hole. The same treatment is effective in disposing of apple and peach tree borers.

Occasionally the hickory shuck worm, *Gramolethe caryana,* proves injurious to the nuts of individual trees.

A number of species of insects beside the common ones here described are to be reckoned with. Mr. Fred E. Brooks, of the United States Department of Agriculture, is situated at French Creek, West Virginia. He will gladly make investigations and offer suggestions for all who apply to him in relation to the subject of nut tree insects.

The almond trees and the nut group of apricots are subject to attack by the common peach borers and an examination of the trees near the ground will reveal the presence of the borers. On the whole, the nut trees perhaps have fewer parasites than any other fruit bearing trees. One reason is that only recently have nut trees been planted in orchard form, giving their enemies an opportunity to increase in orchard form likewise.

Fungous parasites of trees seem to have fewer natural enemies than insect parasites have, although fungi are often destroyed by other parasitic fungi or by bacteria which prey upon them in turn. The same is true of bacterial parasites. There are two chief ways in which a fungous parasite may disappear naturally without any push given by the horticulturist: 1. By way of increase of its natural enemies and (2) by the running out of its stock

of vital energy very much as an epidemic of measles or of smallpox runs out. There are other factors relating to the physiology of resistance that are too technical for inclusion here beyond general statement of the fact. Suffice it to say that an epidemic of potato blight may run out as quickly as an epidemic of scarlet fever, while an epidemic of peach yellows may last as long as an epidemic of yellow fever. Epidemics among plants and animals are caused by microbes, and they include in action the general principles relating to natural law in the organic world.

Some of the fungous parasites of plants may require many years before the vital energy of the family group of these microbes runs out and the epidemic comes to an end. Insect enemies of plants in cases in which both insects and plants are indigenous to the locality have so many natural enemies that one may almost depend upon them. The good orchardist, however, is logically one of the natural enemies. It is probably a fact that microbic enemies of plants have quite as many enemies of their own, but there are so many of both that the tree suffers the fate of many another battlefield.

For many years our butternuts have been gradually dying, and in the vicinity of New York very few of the old butternuts are left. A few dead limbs appear and then the trees have a generally unthrifty look. The cause for this was not known, until recently it was discovered that a fungus, *Melanconium oblongum,* was the malefactor, probably an import from abroad. It now threatens our butter-

nuts quite as seriously as the chestnuts were threatened by *Endothia,* but the time required for the death of a tree is very much longer. Many years elapse before the butternut finally succumbs. *Melanconium* is also attacking the Japanese walnut, and at the present writing we do not know what its destructive range may be in trees of the walnut group. It was described by Mr. Arthur H. Graves, of the United States Department of Agriculture, who believes that it has been with us for at least fifty years.

The word "blight" is a convenient term relating to fungous and bacterial microbes. Parasitic blights which are carried from one country to another are particularly disastrous in new surroundings. The reason for that is that any given blight in its natural habitat has survived in competition with hosts which have learned to resist it by processes of selection in evolution, including help given by natural enemies. When a blight finds itself among new surroundings, on the other hand, it meets hosts which have not learned how to protect themselves in any course of long struggle. Excellent examples of this are the hazel blight, *Cryptosporella anomala,* and the chestnut blight, *Endothia parasitica.* The hazel blight makes little headway among our native hazels and injures very few plants excepting those which have been weakened by age or by accident. When the European or Asiatic hazels are brought to this country, however, they are often attacked so violently that extensive culture of foreign hazels was practically prevented for many years in some localities. We

know now that the hazel blight is readily recognized and it may be trimmed out with the greatest of ease at its inception. It is simply necessary for the orchardist to carry a good sharp pruning knife, cutting out any spots of blight which are observed to be making headway. Just one treatment in a whole year will suffice if the pruning knife cuts are painted in order to destroy any blight spores which might remain.

It is a very different matter with the chestnut blight, which was traced by our Department of Agriculture back to northern China, its original habitat. The chestnut blight in its indigenous home injures the chestnut trees very little, and the Chinese orchardists control it easily by cutting out blight spots, sometimes not even taking the trouble to do this as the fungus makes slow headway with a species of tree which grew up side by side with the blight in the course of evolution.

With increase of the interest in nut culture and consequent transportation of nut stock the chestnut blight has now been carried from China into Europe and into America, being particularly disastrous in our country. The particular part of the fungus known as its mycelium extends in the cambium layer of the tree where it is out of reach of all fungicides. The mycelium rapidly encircles the limb or main trunk of the chestnut tree causing its death.

In the same way if our hazel blight were to be carried to Europe and the Orient it would presumably be quite as destructive there as the chestnut

blight is here, while not harming our native hazels much. Many of the European and Asiatic hazels brought to this country are very susceptible to the blight while others, like the Byzance hazel, are practically immune. The selection then of blight-resisting varieties remains one of the duties of the orchardist.

In regard to the chestnut blight there is much variation in degrees of tolerance shown by different species or by individual trees. Our American sweet chestnut, *Castanea crenata,* appears to be the most vulnerable; next in order in Connecticut come the Japanese chestnuts, then the European chestnuts, and least of all the chinkapin varieties and species. Our own chinkapin, *Castanea pumila,* and its variety, the tree chinkapin, is sufficiently resistant to the blight to thrive many years without becoming attacked, and the same is true of another American chestnut, *Castanea alnifolia,* the alderleaf chestnut. Hybrids between these various chestnuts vary remarkably in their tolerance of blight.

In California a bacterial walnut blight is causing much injury to nuts and foliage. The microbe has not as yet been brought under control, and in fact is spreading to the eastward. The way out of the difficulty has consisted so far in the selection of varieties of walnuts which resist the blight most successfully. Some varieties are extremely vulnerable to attacks from the blight bacterium, while others resist so well that the orchardist suffers comparatively little from the enemy. We must always remember that Nature is quite as much interested in her

microbes as she is in man and his chosen plants. Nature will make a fight to preserve her microbes and will look upon man as being something of a nuisance whenever he discovers a way for getting the best of any species of microbe, insect, or animal.

PART III

Species and Varieties

CHAPTER I

HICKORIES

THE question as to which nut stands nearest to the heart of the American people was easily settled at a time when the author sent out annual prize offers for various kinds of nuts by way of our agricultural papers. The shagbark hickory was the one which introduced by far the largest number of tragedies in making selection for prizes and there must have been as many heartaches as there were after a judgment by Paris. Many of the specimens were sent in with letters expressing an affectionate regard for particular trees, indicating very clearly that the shagbark hickory belonged very close to home feeling. Inferior specimens were sent for prize competition by children with painstaking letters and each one of the children should at least have had a kiss. There were specimens neatly done up in little cloth bags with careful needlework and the accompanying letters expressed hopes that the prizes would be judiciously awarded. There were boastful letters about walnuts and defiant letters relating to pecans but the shagbark hickory was the only one which brought forth expressions of tenderness in feeling.

When people speak of the hickory without qualification they are apt to have in mind some one kind of hickory which belonged to their childhood environment. The names of all other kinds which they happen to know are qualified in some way, very much as the word "fish" in Boston stands for codfish only and "bird" among southern sportsmen stands for bobwhite. In the northeast "hickory" means the shagbark, in Missouri it means the shellbark. Elsewhere the pignut and mockernut are called hickory. Interest in the subject has increased so rapidly of late years that we must now be more particular in our descriptions and add qualifying names, speaking always of the shagbark hickory, pecan hickory, or bitternut hickory as the case may be. Sargent describes sixteen species of hickory and in addition a large number of varieties due to environment and varieties due to hybridization. There is also a Mexican hickory, making seventeen species for the North American continent. The late Mr. F. N. Meyer, Agricultural Explorer from Washington, found a hickory of the pecan group in China. Previous to his discovery it was believed that hickories belonged to the North American continent only at the present day, although fossils indicate their former presence in northern Asia before the ice cap made trouble.

It is not improbable that a number of species of hickory not yet described may be found in this country. So distinct and notable a species as the Buckley hickory, *Carya Buckleyi,* common in the forest regions of eastern Texas and the Ozark hills of Okla-

homa, was described by Buckley in the *Southern Horticulturist* for May, 1870, was given notice by Mrs. M. J. Young in *Lessons in Botany* three years later, and then apparently passed out of mind among botanists for forty years. It has recently come into notice again.

Botanists divide the hickories into two groups—*Apocarya* and *Eucarya.* For convenience in everyday conversation it might be well for us to speak of the "open-bud" group and the "closed-bud" group. *Apocarya* or the open-bud group includes the pecan hickory, bitternut hickory, bitter pecan hickory, water hickory, nutmeg hickory, and Chinese hickory. The winter buds of this group will be seen on examination to show minute snugly curled-up leaves which are all ready to unfold when a gentle springtime sun coaxes open the fronds of the ferns which have fought their way through the hard ground with clenched fists. Bud scales in the open-bud group do not cover the tiny leaf forms completely. In *Eucarya,* or the closed-bud group, on the other hand, stout scales close the bud completely against the snow and ice of wintry days. We see scales only, when looking at this kind of bud. There is no suggestion of the great loose mass of beautiful fragrant leaves that will come bursting out like an explosion on a warm day in May when trout are rising to the fly and robins are singing in the orchard.

Hickories which have nuts with a bitter pellicle all belong to the open-bud group. These are the bitternut, *Carya cordiformis;* bitter pecan hickory,

Carya texana; and water hickory, *Carya aquatica.* Hickories with scaly bark are found in both open-bud and closed-bud groups. In the open-bud group the water hickory carries long loose bark strips hanging to the trunk and in the closed-bud group we find the same characteristic belonging to the shagbark, *Carya ovata;* and the shellbark, *Carya laciniosa,* Carolina hickory, *Carya carolinæ-septentrionalis,* and to one of the pignuts, *Carya ovalis.* That takes us to another question. What do we mean by "pignut"? In the north this term is applied to *Carya glabra* and *Carya ovalis.* In the south it is applied to *Carya cordiformis.* A name so well established will have to be retained but it will perhaps be best to have an understanding about which one of the hickories is to keep the common name pignut in view of the fact that the pigs themselves give this name to seventeen kinds of hickories. So long as the name covers two species in the north as opposed to one in the south there are already two votes to one in favor of retaining the name pignut for *Carya glabra* and *Carya ovalis.* We may describe these in plain language as the smooth-bark pignut and the loose-bark pignut. The reason for choosing the name "loose" instead of "scaly" is that we are pretty well agreed upon applying the name "scaly-bark" to the Carolina hickory, the name "shagbark" to *Carya ovata,* and the name "shellbark" to *Carya laciniosa.* The name bitternut may be safely allowed to remain with *Carya cordiformis* because it is surely bitter and because the other two nuts with bitter pellicle already have dis-

tinctive names. *Carya aquatica* being called "water hickory" and *Carya texana* being called "bitter pecan." By anchoring fixed points in nomenclature in this way we may ride out the confusion which would otherwise become worse confounded as the interest in hickories becomes rapidly enlarged, if committees on nomenclature do not take some decisive step in the matter.

Concerning Latin nomenclature we have further troubles for settlement. *Hicoria* is the older generic name and naturally should have priority but the Vienna Congress of Botanists adopted *Carya.* So far so good (or bad). Now comes our trouble in giving specific and varietal names. The binomial is clearly applicable enough for species, *Carya pecan,* for example, but when we come to varieties of the pecan there are two kinds of varieties to be considered, those by natural variation and those by hybridization. In cases of natural variation we are within accepted resources in nomenclature by saying *Carya pecan, var. Stuartii.* When naming hybrid varieties, however, I would suggest that in advance of the abbreviation "var." we place the abbreviation "hyb." Thus reading for Brown's pecan *"Carya pecan, hyb. var. Brownii"* instead of *Carya Brownii,* which latter binomial would throw it among the species instead of among the varieties. In view of the fact that we are to have hundreds of named hybrids to deal with shortly it seems to me that we must adopt some such definite method for convenience promptly. This method of naming relates to convenience only

and is applied to the most evident parent among hybrids. As a matter of fact in horticultural circles we are doing precisely that sort of thing already, speaking, for example, of "Brown's pecan," and meaning by that a nut which we recognize as being a hybrid, brought to public attention by Brown but with the pecan as the parent most strongly in evidence.

When I was a boy the only hickory nuts of any sort available were those collected from wild trees. The popular boy was the one who knew of some tree which furnished the best nuts and who did not keep the news to himself but looked upon the owner of the tree as a public benefactor, regardless of what the owner thought about it. The squirrels knew the best nuts as well as the boys did and they would go past many other hickory trees in order to congregate in some one tree which had nuts with the thinnest shell and plumpest meats of best quality. The squirrel is classed among the dumb animals by theologians but in the early morning hours I have seen several squirrels in one particularly good hickory nut tree and not a single squirrel in a tree laden with second rate nuts but with its branches touching those of "the bully tree." Here and there attempts have been at propagating fine hickories of various species by planting nuts. It is not as yet generally known to people excepting botanists that the varieties of hickories are so thoroughly crossed, like varieties of apples, that they will not reproduce true to type from seed. The Schley pecan will not produce Schley pecans

from seed for the same reason that the Baldwin apple will not produce Baldwin apples from seed.

SHAGBARK HICKORY

When the question of quality of kernel is to be considered there is little doubt but the shagbark stands highest among the hickories. The Indians called it "kiskitomas." They pounded up the nuts, shell and all, in water and poured off the emulsion allowing it to ferment. The drink was then called pawcohickora, so far as the first drink was concerned. History does not tell us the pronunciation after subsequent drinks. This hickory milk added to venison broth or employed in making nice hot corn meal cakes, doubtless put the Indians in a kindly mood favoring the trader. Roasted sweet potatoes were crushed in hickory milk and eaten by the Indians. The sweet emulsion partially evaporated and stored in earthern jars made a thick rich cream which had excellent keeping qualities when hidden in a safe place. Hickory nut oil pressed from seasoned shagbarks was a staple article of diet among the Virginia colonists. Associations with the shagbark include memories of cider and apples and a flatiron held between the knees before an open fireplace. People never gather about a radiator excepting when waiting for a train or when looking for something that has rolled under it.

Although shagbark nuts have a general character which belongs to all, hardly any two trees yield nuts

with precisely similar flavor. There are almost as many variations of flavor as there are of faces of people, all alike in a way but no two just alike. Some of the most exquisite flavors are found in small nuts and committees on prizes do not reckon size as counting first place with this nut. Flavor comes first, then cleavage or cracking quality, followed by thinness of shell, size and color. Investigators into the question of thinness of shell found that this characteristic had its limitations. Shagbark trees were found bearing nuts with a shell so thin that it could be easily cracked in the hand holding two nuts. Brittleness of the shell, however, caused it to crack very much like an egg shell only at the immediate point of application of force. A hickory nut with a shell which allows of free cleavage and the dropping out of the kernels in halves is better than one with a very thin shell which cracks only over limited areas in response to pressure or a blow.

Mr. Willard G. Bixby, of Baldwin, New York, who is at present giving close attention to nut questions in a thoroughly scientific way has the feeling that some of the best nuts that are called shagbarks really represent hybrids between species rather than varieties. Many of the most desirable hickory nuts which are now being cultivated are know to be specific hybrids. Some of these are more prolific and more precocious in bearing than any of the pure shagbarks. The original Weiker tree, for example, has a record of twelve bushels to the crop while very few pure shagbarks will yield three bushels to the

crop of husked nuts. The wild shagbark tree growing under conditions of competition with grass, bushes, and other trees may not bear a nut before it is twenty-five years of age, yet scions from this tree when used for top-working other stocks may begin to bear in two or three years from the time of grafting. Some of the shagbark hybrids are more precocious than either parent in bearing. Mr. Bixby is applying the seedling test to hickories about which there is a question of parentage. He plants a number of nuts from a given tree and then observes if the progeny throw back to more than one species when they are growing.

In hickory grafting much experimental work remains to be done in the choice of stocks for grafts of different species. On one occasion a lot of more than two hundred shagbark hickory trees grafted on pecan roots for me in the south lived through their first winter at Stamford but in the following spring weather conditions happened to be such that one morning I found the pecan stocks all burst open and killed. The lesson was that northern pecan stocks should have been used for grafting. In all probability the southern roots had moved the sap into the stocks freely at too early a date and then one freezing at night sufficed to congeal the sap and burst the bark away from the wood. Almost all of the hickories that have been grafted upon northern pecan hickory stock seem to do pretty well upon that stock, but the converse is not true. The pecan apparently does not always do well when grafted upon

other hickory stocks, even upon those of its cousins, the open-bud group. The shagbark hickory in my experience to date has done best upon stocks of the shagbark, mockernut, or pignut. A number of years, however, are required in some cases for determining that point. Shagbarks which I have grafted upon bitternuts have sometimes made a remarkably good start. Then at the end of two or three years they begin to slow up while shagbarks on shagbark stock, starting slowly at first, surpassed the ones on bitternut stock. This may not prove to be true of other localities, and we may find that the pecan stock or some hybrid stock for shagbarks will work out best finally.

Trees like the hickories, which have a determinate growth, are for the most part not renewed rapidly from sprout growths when the trees have been cut back severely for grafting purposes or otherwise. Shagbark hickory acts very differently from the poplar or willow tree in this respect and may make such very small growth for three or four years after being cut back that the new top would seem to be hardly sufficient for supporting the root system. In the shagbark the annual growth in length of the shoot is made in about six weeks in the springtime in Connecticut. The top bud is then formed and increase in diameter of the shoot continues for some weeks thereafter. If we cut a twenty-five-foot shagbark hickory tree back to ten feet for grafting purposes one might suppose that the enormous root would send new growth shooting toward the skies in

the following year as would be done by the peach. Such, however, is not the case. Grafts placed in such a stock that has been cut back to ten feet or natural sprouts starting from the latent buds may make only a few inches of growth before putting up top buds in the first year, and not much more than that in the second year. A good many years of growth are required before the balance is restored between top and root in the shagbark, although the top may begin bearing freely a long while before this balance is restored.

Grafts of the hickories will sometimes make a growth of two or three inches of new shoot with good looking leaves, and these suddenly begin to wilt and die back unaccountably. We may perhaps find explanation for this phenomenon in Loeb's theory that hormones furnished by the stock for shoot building are not always adapted to the chemistry of the new shoot. It dies back before the leaves are well enough developed for exerting an influence upon the stock with their own hormones.

For the most part, however, hickory trees of all sorts may now be propagated as easily and as successfully as apple trees following the plans described in the notes on grafting. The best dealers in hickory nursery stock sell only grafted varieties that have been chosen because of special merit. The shagbark hickory, *Carya ovata,* has a natural range extending from lower Canada to western Florida and from the Atlantic seaboard to central Kansas. A species with such range in adaptation may probably be

grown throughout the larger part of the United States, and doubtless will be so grown now that market varieties bringing high prices for their nuts may be bought from nurserymen. The shagbark is at its best in the northern half of its range, and we may expect that it will be to orchardists of the north what the pecan hickory is to southern nut growers.

PECAN HICKORY

While the shagbark hickory stands first in rank for the quality of its nuts the pecan hickory surpasses it as a market product up to the present time, and likely enough will continue to hold that position. We do not buy Holstein milk for flavor if we can get Jersey, Ayrshire, or Guernsey milk, but the Holstein people dominate the market. A fundamental point is one relating to abundant production. The pecan hickory bears enormous crops of nuts. Furthermore, kernels of pecan nuts are extracted with such facility by machinery from some of the varieties that a great and delicious food supply is put on the market with ease. Many of the small, undersized varieties of pecan nuts have high quality, and this is true of some of the larger kinds also. People who accept Holstein milk, Elberta peaches, Ben Davis apples and Kieffer pears without a whimper, buy also the very largest thin-shelled pecans. Very likely the public will become educated in the matter later. We have passed the point where people of discriminating taste step into the market and simply ask for large red apples. When the market man asks

about the kind of apples wanted the answer calls for Spitzenberg, Mackintosh Red, or Delicious, as the case may be. Up to the present time the public in general is not past the point of calling for large paper-shell pecans. That is much like calling for large red apples. To-morrow when buying pecans people will presumably ask for the Schley, the Posey, the San Saba, or some other pecan that is purchased for some well-defined reason.

The commercial side of hickory raising is being worked out for the pecan only, as yet. We may assume that several of the other species of hickory adapted to growing in the north will compete with pecans in importance eventually. The reason is that some of the other hickories stand quite as high as the pecan in food value and general excellence aside from the quality question. At the time of writing low grade seedling shellbark nuts from the west are selling in the retail market in New York for twenty-five cents a pound. I have seen nuts of this species being loaded on cars in Ohio at fifty cents a bushel. The present New York price, to be sure, represents profiteering. Fine grades of shagbark hickories and some of the hybrids will command prices equally high with prices for best pecans.

While the timber of the pecan tree is not so valuable as that of several other species of hickory, the raising of pecan nuts has progressed to the point where, at the present moment, this promises to rival the black walnut as the most important species of

nut bearing tree in the United States. Its natural range is from southern Indiana and Iowa southward into Mexico. Pecan trees of different groups belonging to three distinct belts have been described by Mr. Meredith C. Reed, of Vincennes, Indiana. For purposes of planting, trees of the Indiana or Iowa groups are the only ones which are likely to be extended farther to the north. So long as the shagbark hickory range extends from southern Ontario southward beyond the indigenous range of pecan hickories of the northern belt, it will probably be desirable on the whole to develop the shagbark hickory in the north instead of attempting to extend the range of the pecan very widely in that direction.

A natural check to the northern distribution of the pecan hickory no doubt relates to its long growing season. The shagbark puts terminal buds on its shoots after about six weeks of growth in the spring, but some of the pecans do not put up top buds until more than twelve weeks of growing season have elapsed. Female flowers are borne upon the ends of shoots of the year and buds for these flowers as well as the growing nuts may not have time to mature before the first frost nips them in the north.

The most northerly bearing pecan that I know about is a seedling on the Dana estate at Glen Cove, Long Island. There are two large bearing pecans about one hundred years old on the Lorillard estate at Jobstown, New Jersey. The nuts are small, but good. Farther north there are several large and thrifty pecans in Westchester County, New York,

and one on the Capitol grounds at Hartford, Connecticut, but I do not know of a pecan tree north of Long Island that matures its nuts. We may find in the future that some of the pecans from Indiana or Iowa will grow and ripen well-filled nuts as far north as southern Ontario, but as a commercial proposition, however, we had better leave the development of the pecan to the area south of Mason and Dixon's line for the most part. Difficulties increase beyond the pivotal point when any tree is carried far out of its natural range, and on general principles one may expect to get much better results in the north from trees which belong to the north. Several of the hickories, walnuts, and hazels are worthy of as much attention in the north as has been given to the pecan hickory in the south. The development of the pecan in the south has become a matter so highly specialized that I shall make only casual reference to the subject in these pages, leaving the investigator to obtain his information from the literature of the transactions of the National Nut Growers' Association and from books like that of H. H. Hume devoted wholly to the pecan.

Aside from the market proposition there will undoubtedly be much interest in the north in raising certain kinds of pecan trees which may be grown to advantage for household purposes without regard for the market question. Let us make comparison between the pecan and the large extension of range belonging to other fruit trees. Most of the fruit trees belonging to cultivation were the ones which

belong to southern Europe, Asia, and northern Africa. The range of these was gradually extended northward until the limits of successful cultivation were reached. The reason that northern fruits had not been developed simultaneously to meet northern conditions was that people who first cultivated plants and domestic animals gave attention to the ones living where man was first developing a high degree of civilization. As man went farther north he took warm country plants and animals with him.

Elaborately specialized work in pecan growing is of recent origin. It seems to indicate what we may anticipate in the history of other kinds of nut trees. Cattle raisers now have their Holstein Societies, Guernsey Societies, Devon Societies, et cetera. The time is doubtless coming when Shagbark Societies, Shellbark Societies, and Scalybud Societies will hold their annual meetings. Each will elect a chairman to correct overstatement on the part of enthusiasts, appoint committees, and complain of the complications relating to the proper understanding of so large a subject.

Interesting experimental work is to be done in finding the extent to which different species and varieties of hickories may be grown out of their indigenous range. At Stamford, Connecticut, the bitter pecan hickory, *Carya texana,* from Texas, appears to be perfectly hardy but it makes very slow growth, sometimes not more than an inch in a year. The Buckley hickory, *Carya Buckleyi,* on the other hand,

also from Texas, grows thriftily at Stamford and so does the Carolina hickory, *Carya carolinæ septentrionalis.* The latter has a rather limited natural range, and by analogy we may assume that this species will never have quite the cultivation range of the shagbark hickory and shellbark hickory. The small, thin-shelled nuts of the scalybark hickory are of such high quality that we may select those of some of the varieties for dessert purposes, to be cracked like hazels at the table with a small hand cracker.

THE SHELLBARK

The shellbark hickory, *Carya laciniosa,* produces very large nuts with a kernel approaching that of the shagbark and scalybark in quality. The nuts have such a thick shell, however, that they are mainly interesting to boys and to men out of work. The kernel is a prize when we finally get hold of a piece of it. Somebody may discover a tree of this species bearing thin-shelled nuts, but the thick shell belongs so closely in harmony with the magnificent sturdiness of the tree as a whole that Nature even in freakish mood is not likely to go so far as to flat the harmony with anything like a thin shell for the nuts of this species. The tree has a natural range extending from southern Michigan to Arkansas, and from eastern Kansas to middle North Carolina. The splendid vigor of the species leads Mr. Bixby to pre-

dict that it may become a valuable grafting stock for other hickories, and we already have some first-rate hybrids including the shellbark as one parent.

PIGNUTS

The smooth bark pignut, *Carya glabra,* and the loose bark pignut, *Carya ovalis,* bear nuts with sweet kernels but lacking lively quality. Shells of the nuts of both species are thick and the cleavage seldom good. Both kinds may be grafted with fine shagbarks.

MOCKERNUT

The mockernut, *Carya alba,* bears large crops of thick-shelled nuts with a peculiar flavor which does not appeal promptly to the palate with most people. The tree will flourish on such poor sandy and gravelly soil that it may serve as grafting stock for varieties of more choice species which cannot be grown on their own roots in such soils.

BUCKLEY HICKORY

Another thick-shelled nut, that of the Buckley hickory, *Carya Buckleyi,* has a kernel of distinctive flavor and odor which has not as yet called for much comment. Personally I find myself cracking and eating Buckley hickory nuts at times as a matter of unconscious choice, but one will not keep at it to the

neglect of engagements, as is the case when high class shagbarks and pecans are at hand.

None of the remaining species among the hickories call for attention from the gastronomic point of view, but for grafting stocks and for lending paternal influence to hybrids many of them will come into prominence from time to time. All of the hickories have timber value, some of the species ranking very high, but the nut grower is not interested in this feature of the subject. His trees planted for crop income purposes do not develop trunks of the sort required in the industries.

When purchasing grafted hickories from the nurseryman we must distinguish between kinds for home purposes and kinds for market. For example, the Leonard is a thin-shelled shagbark of highest quality and so small that it may be cracked with a hand cracker at the table. Furthermore, it will keep without becoming rancid or dry for three or four years under ordinary garret or cellar conditions. The ordinary buyer in the retail market would no more look at this nut than he would look at the San Saba pecan, yet both are standard for quality, cleavage and thinness of shell.

The Weiker hybrid, on the other hand, is a very large hickory nut of fine appearance and quality that is good but not best. The shell although rather thick is easily cracked with good lines of cleavage. The tree is precocious in bearing and so prolific that the market grower may be very sure of profitable returns from its large crops.

Midway between the Leonard and the Weiker stand such hickory nuts as the Vest and the Taylor of medium to large size, thin shells, first rate cleavage and high quality of kernel. Both trees yield only average sized crops of nuts. The Taylor, unlike most hickories, however, may bear regular crops for several years in succession instead of in alternate years. Dr. William C. Deming has had it in bearing by the third year after top-working.

Hybrid hickories like Beaver and Laney with medium to large thin shelled nuts of good quality catch so readily on so many kinds of stocks that the orchardist would prize these for top-working old field stocks. The catalogues of reliable nurserymen include so many kinds of grafted hickories that I am giving here simply a brief account that will suffice for allowing the amateur to know that his subject is a large one.

CHAPTER II

WALNUTS

OUR native North American walnuts include several well-defined species and in addition several kinds about which there is dispute in regard to the question of variety rather than species. For the purposes of these notes we may leave out points in controversy and make comments upon walnuts which are of immediate importance from the orchardist's point of view. Among these we have the butternut, *Juglans cinerea;* the black walnut, *Juglans nigra,* and its near relatives, the California walnut, *Juglans californica,* the Texas walnut, *Juglans rupestris,* and the Arizona walnut, *Juglans major.* From abroad we have brought the Persian walnut, *Juglans regia;* a Chinese walnut named *Juglans sinensis,* but now held to be only a varietal form of *Juglans regia,* and two Japanese walnuts, *Juglans Sieboldi* with its varietal form, *Juglans cordiformis.*

PERSIAN WALNUT

The name Persian walnut for designating *Juglans regia* has been chosen in order to avoid confusion that goes with such names as French walnut, Eng-

lish walnut, Chile walnut, Madeira walnut, and other names which have been applied to this species away from its original habitat in Asia. In this country it is commonly called English walnut because it was brought here from Spain and France by missionaries and because the chief importations are from France and Italy. If there are any other reasons for applying the name English walnut to the species the author is not clear on the subject.

Commercially the Persian walnut now stands alongside of the pecan hickory among nut trees which are being cultivated for market purposes in this country. Trees of this species have been developed in so many varietal forms in different countries that we now have nuts ranging in size from the enormous Gant, used for a jewel casket, down to nuts no larger than hazel nuts, which are crushed shell and all for the extraction of the oil. Medium sized kinds of walnuts with thin shell and high quality of kernel are the ones chosen for market purposes in general. Among these the Mayette, Franquette, and Parisienne may stand as being representative of all that is best. Different varieties of the species are pretty well distributed over almost the whole of the temperate parts of the northern and southern hemispheres. This aristocratic nut tree, however, is a stickler for suitable conditions of soil and climate, but *noblesse oblige,* and for that reason various forms which adapted themselves to certain kinds of soil and climate vary greatly in characteristics from others which adapted themselves to other

kinds of environment. We cannot be at all sure that a valuable kind of Persian walnut from France, China, or Brazil will adapt itself to the conditions found in any one part of North America until we have experimentally proved out the fact by the actual raising of trees. On the Pacific coast of North America, particularly, this work has been developed with such a degree of enthusiasm that very many varieties of the species stand for high value under varietal names which have been given them. Among thousands of seedling trees which have been raised some are superior in certain respects to the parents from which they sprang.

California has taken the lead in walnut growing with a climate and soil particularly well adapted to the needs of the species. Mr. Carlyle Thorpe, of the California Walnut Growers' Association, announced for 1920 a walnut crop estimated at 46,000,000 pounds, having a value of $15,000,000. In addition 50,000,000 pounds of walnuts were imported during the nine months preceding Mr. Thorpe's report. The time is not far distant when the importation of walnuts will be less than our production. Development of the subject has been the outcome of careful selection of varieties, the determination of the best grafting stocks suitable to northern and southern California conditions and to coöperative marketing. The latter feature is of great importance. The growers of certain districts are responsible to a body of market experts who take charge of the crop, attend properly to grading and selection of the nuts and

to the disposition of culls and undesirable nuts in the most economical way. In former years these undesirable nuts which could not be sold among people who knew about good walnuts were sent into eastern markets where they promptly killed the market for California walnuts. A similar history relates to the pecan. Fine varieties have been bought up locally while some of the larger pecans, poorly filled and of low quality, not salable at home, were sent to the markets of the northern cities where they disabled the whole pecan market before pecan growers adopted coöperative marketing. The California Walnut Growers, under the management of Mr. Thorpe, have overcome these market difficulties and they have invented and applied expensive machinery for preparation of the walnut crop for market beside placing a check upon individual growers who would send inferior nuts to retail markets. Oregon is following California rapidly as a nut-growing state.

The Persian walnut when grown on the Pacific slope introduces one notable feature. In former years delicious nuts from the Grenoble district in France led the market with varieties which were used chiefly for dessert purposes. These varieties will probably continue to hold the market for such purposes because of the superior quality of the French nuts. On the Pacific slope, however, Persian walnuts of many varieties all have a common tendency to develop a notably plump kernel with carbohydrate or starchy elements in such abundance

that the plain food value of the nut has been very much enhanced even though the nuts have lost in delicacy. This food value question is important to such a degree that quite a new aspect is given to walnut culture. A nut which is somewhat deficient in flavor but large and beautiful in appearance is made still more beautiful and less delicious by any sort of bleaching process. French growers knew better than to injure quality in favor of appearance and for that reason will hold the discriminating trade. The general market in our country seems to call for bleached blondes a little off in character. The natural walnut shell has a subtle fragrance, elusive but always present. It is like the bouquet of a delicate wine. Bleaching lessens this "life aroma" and leaves the kernel with a lowered quality like that belonging to shelled kernels. The latter are pretty good—well worth the having, but not the best. If a California walnut grower will select some medium sized nut of highest quality and send it to the eastern market unbleached but at higher price than any bleached nut he will establish a sort of market requiring no talking or advertising.

In eastern North America little was known about our Persian walnut trees at the beginning of this century, although many seedling trees existed. Mr. J. G. Rush, of Lancaster, Pennsylvania, is probably the father of our eastern walnut growing. As a result of investigations by Mr. C. A. Reed, of the Department of Agriculture at Washington, and by members of nut growing associations, many hun-

dreds of seedling Persian walnut trees have now been located in the east and as far north as southern Ontario. Only a comparatively small proportion have been found to bear particularly valuable nuts. The same is true, however, of the seedling trees of the Pacific coast and for those of other countries, for that matter. (Mr. Reed is a general authority on American nut questions and may be reached through our Department of Agriculture.)

CHINESE WALNUT

It is now believed by many botanists that the Chinese walnut, *J. sinensis,* should not have been given a specific name and that it is only a varietal form of the Persian walnut. Should this be the case we may profitably do a good deal of experimenting with the Chinese variety in the eastern United States. It is very hardy and in China grows in much colder regions than those in which Persian walnuts of European origin will thrive. Nuts of the Chinese tree have a rather thick shell and the kernel is rich but not delicately flavored. Among several hundred seedling trees, however, one would be pretty sure to find individual specimens with thin shells or with delicate flavor, or both. These trees would be best for northeastern development, because it is a rule that trees of all sorts from the eastern Orient adapt themselves to our east much better than do European trees. Chinese walnuts may be obtained in quantity from importers.

Persian walnuts of European parentage are prone to be capricious in our country east of the Rocky Mountains. In suitable ground they grow thriftily and bear heavily. There are many valuable trees of this species here and there about the country, some of them in orchard form. On the whole we shall do better in the east with other kinds of nut trees for large market production, growing Persian walnuts of European varieties only in those localities in which they are known to be contented with conditions of climate and soil.

There is a tendency for all Persian walnut trees to store up tannin in the pellicle of the kernel and likewise certain bitter elements. These may render the nut low grade if not actually unpalatable from some trees. Such was the case with a large lot secured by the author from Thibet. Here and there a seedling tree bearing nuts of remarkably fine quality has been found. Propagation from such trees is now under way experimentally throughout a greater part of temperate North America. The Persian walnut seems to thrive best upon stocks of the eastern black walnut. Black walnut trees grow with great vigor and on the whole to a larger size than the Persian walnut, consequently this relative excess of vigor is passed over to the Persian walnut grafted upon black walnut stocks.

Propagation of the Persian walnut has formerly been found to be difficult at the hands of most horticulturists. Even in the Grenoble district in France, the home of experts in walnut growing, every village

has some one man who is more famous than all of the rest for his grafting. Such a man is sometimes called to long distances and for large pay. About the same story belongs to our Pacific coast region. Let us hope that methods of scion grafting and of bud grafting described in a foregoing chapter may make it possible for walnut growers in all countries to dispense with experts in this part of their work. Furthermore, instead of hurrying to do walnut grafting in the course of a few days in spring and in late summer the orchardist may now do the work leisurely during at least four months of the year.

The Persian walnut lives to a great age under favorable surroundings in the Old World, producing abundantly for several centuries. It must be given a great deal of room. I have been in California orchards where trees set only sixty feet apart were already touching branches with each other while they were yet young. This meant inferior crops, inferior quality of nuts, and lowering of resistance to disease. Trees set one hundred feet apart would have been much better off. Intercropping with hazels or with small hybrid chestnuts would have made the land profitable with nut crops, and these smaller trees might have been cut away as fast as the walnuts reached out to them.

There was a tradition in France to the effect that walnut trees required a great deal of lime in the soil. In some districts lime was carried to the trees every year. A commission appointed for the purpose of examining into the question came to the

conclusion that lime simply helped to unlock from the soil a certain amount of potassium, phosphoric acid and nitrogen. When these three essential elements were added in fertilizer the lime was not needed at all.

Persian walnut trees are frequently self-sterile. A single tree standing alone far from its kind may not bear a nut until company is furnished. For that reason it is well to have at least two varieties of the species in any one orchard. Species will sometimes suffice for social purposes instead of varieties. For example, the black walnut hybridizes freely with the Persian walnut.

None of the nuts from hybrids between the Persian walnut and other walnuts have as yet shown any especial value, but we have at least one remarkable timber tree resulting from a cross between this species and the California black walnut.

The Persian walnut comes fairly true to type from seed, but seedling trees are so prone to be unfruitful, or to represent inferior ancestors, or to require many years before coming into bearing that nothing but grafted trees should be planted by the orchardist unless he feels that he can afford to experiment.

BLACK WALNUT

Which one of our trees is to be the "National Tree"? The Editor of *American Forestry* has asked to have the matter put to a vote. The press is now asking readers for expressions of choice. Many

have spoken for the black walnut, and the author heartily joins this group. Some correspondents are insistent upon beauty as a prime desideratum, while others demand utility. In the black walnut we have a combination of both characteristics. The typical tree of the species has a majestic, free and bold uprightness which may very well stand for the American spirit. Early dropping of the foliage in autumn is held to be an objection by some writers, but this baring of the sturdy branches reveals a wealth of fruitfulness developed during the busy season of the tree and now held aloft on display to serve as inspiring evidence of work well done. Those who object to this feature of the tree may choose a variety like the Stabler, with its attractive disposition of limbs and beautiful foliage which persists later than that of other black walnuts. Universality is a point in favor of this tree which thrives from lower Canada to the Gulf of Mexico and from the Atlantic to the Pacific coasts. This probably means further that it may be grown in almost all of the temperate regions of the world—a range quite as great as that of the Persian walnut. If the Old World has given humanity one tree in particular that is wonderful for a combination of looks and usefulness the time has come for the New World to make graceful reciprocation. We may do it with the black walnut and at the same time leave no doubt as to which country has made such a contribution to man's welfare.

The author speaks for the black walnut as our national tree at the risk of displeasing advocates of

the pecan hickory for that position. There can be no other trees in the contest if usefulness looms large among score points. It would be a pity to choose any tree to represent our United States with utility features playing in second rôle. Both trees are majestic giants in strength. Both bear prodigious crops. Both species during the present century will be grown from Canada to the Gulf of Mexico and from the Atlantic to the Pacific coast. Delicacy of the pecan nut will be balanced by richness of the black walnut in score points. The pecan is the more purely beautiful excepting for selected varieties, but the value of the black walnut timber far exceeds that of pecan timber and the hulls and shells of black walnuts enter into special fields in the industries aside from the comestible value of young nuts preserved like those of the Persian walnut.

Mr. T. P. Littlepage at the Seventh Annual Meeting of the Northern Nut Growers' Association presented a photograph of curly black walnut wood from a tree in Kentucky which brought thirty-five hundred dollars. If scions from that tree had been employed for grafting several thousand other black walnut stocks, the timber value alone regardless of the nut crop would be worthy of a few minutes spent with pencil and paper. A peculiar variety will develop its own type of wood as well as its own type of fruit when grafted upon other stocks. Black walnut trees of the ordinary type of wood sometimes reach one hundred and fifty feet in height, with a trunk diameter of more than six feet. The

timber value of a single tree of that ordinary sort may reach two hundred dollars. Orchardists are concerned with the nut values of the black walnut only, and this note upon other features is made briefly in passing to the main topic.

Not much attention was given to the nuts of this species previous to the year 1900. The reasons for such neglect are easily stated. In mixed lots of nuts from uncultivated trees the shell was usually thick and cleavage exasperating. Each nut when cracked would commonly go into four chief pieces, and each piece required separate cracking. In due time small bits of kernel extracted were found to be of good flavor or poor, as the case might be. Some of the nuts have a tough kernel and strong taste; others have a tender, rich and deliciously flavored kernel. The time came when cake bakers and confectioners began to ask for black walnuts of the right sort, and Mr. E. A. Riehl selected for propagation one variety which he named the Thomas, the nuts of which brought eight dollars per bushel in 1918. Some of the trees yielded fourteen bushels each, and comparatively young trees at that. There are records of yields of from thirty to forty-five bushels of unhulled nuts per tree from mature trees of this species. For market purposes black walnuts are hulled while yet green in color and dried quickly. This avoids discoloration of the kernel, which occurs if dark fluid from the moist hull finds its way through the shell. By selection we now have several grafted varieties of black walnuts, with fine quality and light

colored kernel, excellent cracking cleavage, and shells much thinner than those of the common run. One of the members of the Northern Nut Growers' Association, Mr. Webber, found a black walnut in the sand of a small stream emptying into the Ohio River. It had a shell no thicker than that of the Mayette Persian walnut. In the following year he found another nut of the same sort carried down by the same stream. Somewhere overhanging that creek is a black walnut tree of inestimable value if it can be found and if the quality of the kernel is good. We shall find many kinds of black walnuts suitable for propagation purposes. Grafted stock of the Stabler, Thomas and Ohio varieties is already available from nurserymen.

The United States Department of Agriculture has brought forward for some years a black walnut known as "the peanut." The nut probably represents a flower bud defect, bearing a kernel in one compartment of a defective shell. Not all of the branches of the tree bear this particular freak, which is desirable because the kernel comes out whole when the nut is cracked. In all probability we may make bud selection by marking branches which bear the freak nut and then produce desirable trees from grafts chosen by such selective budding.

Perhaps the chief reason for neglect of propagation of the black walnut in the past has been due to difficulties in grafting. The story told me by an old hunter and trapper may doubtless be repeated with variations by others:

"When I was a boy there was a black walnut tree down by the river that had nuts as good as candy. One spring we got to talking about it. Two or three of us cut some grafts and my father put them in a couple of young trees back of the stable, but the grafts did not grow. I never heard about the ones that were put in by the other fellows."

The difficulties in black walnut grafting have now been disposed of by the new method. The author has caught black walnut grafts freely not only upon stocks of the same species but also upon stocks of the Japanese walnut, the Persian walnut, and the butternut. Any one with money enough for buying a good dinner has money enough for buying a grafted black walnut tree. The dinner would quickly belong to past history, but the tree might live for a couple of centuries and bear several thousand dollars worth of nuts.

As a purely business proposition the black walnut orchard at the present moment probably offers opportunity for as secure an investment as may be made in any department of agriculture. Ordinary nuts of this species are now selling in the New York retail market at twenty-five cents per pound, and the trade is unable to get varieties of the sort that it asks for by the ton. The tree will do its best in deep, rich, well-drained soil of neutral or alkaline reaction, but some of the most beautiful black walnuts that I have seen are growing in thin, poor, sandy soil on Long Island, where little else beside scrub oaks, pitch pines, and blueberries thrive. In such

soil of the acid reaction type the trees grow more slowly than elsewhere, but on Long Island everything has plenty of time at its disposal.

CALIFORNIA WALNUT

The California black walnut, *Juglans californica,* corresponds rather closely to the eastern black walnut, excepting that it is a much smaller tree. The wild nuts have sufficient value to make their collection for market purposes in small quantities worth while. The tree belongs to the California coast region, and was formerly used there extensively as grafting stock for the Persian walnut. The larger size of the eastern black walnut tree and the fact that it seems to thrive as well on the Pacific coast as it does on the Atlantic coast has caused the eastern tree to be chosen lately for grafting stock.

BUTTERNUT

Among our native walnuts which have market value the butternut, *Juglans cinerea,* has been the more highly esteemed, perhaps, on the whole, for home use and for the wayfarer. The rough shell of the nut and comparatively small size of the kernel have kept the market price low and the demand limited. Hybrid forms of the butternut are now being developed in such a way that we may eventually have thin shelled nuts of large size carrying desirable qualities of the butternut parent. The ma-

jestic tree, sometimes a hundred feet in height and the trunk three feet or more in diameter, has been a feature of the landscape throughout the range of the species from southern New Brunswick to northern Georgia and Alabama. The tree is a favorite in the autumn with nutting parties, and the bushel or two of dried butternuts in the attic furnishes an enjoyable feature of farmhouse provender that is stored up for winter evenings by the fireside. Sugar is made from butternut sap and the immature nuts are pickled. There is danger of disappearance of the wild butternut now that the fungous parasite *Melanconium oblongum* has grasped this tree in its clutches. The fungus grows very slowly, however, and may not kill a tree in twenty years from the time of the first attack. The spores usually enter at some point of injury. If dead branches are cut out promptly and all exposed wood covered with protecting material we may preserve our orchards of grafted trees in a flourishing condition of health with no more trouble than that belonging to an apple orchard. Aside from the prospective cultivation of superior hybrid varieties of butternuts we may profitably grow a limited number of grafted trees of the species which bear particularly good nuts. There are many lovers of the butternut, and the trade is calling for more than the producers are now supplying, although the outlook is not to be compared with that of the black walnut, Persian walnut, pecan hickory and hazel. As a grafting stock the butternut accepts Persian walnuts, black walnuts, and

heartnuts freely. Such being the case wild butternuts may now be top-worked with kinds which have immediate market value, leaving a few which bear delicious nuts for home use.

TEXAS AND ARIZONA WALNUTS

The Texas walnut, *Juglans rupestris,* is found in western Texas, New Mexico, and northern Mexico. The Arizona walnut, *Juglans major,* is closely allied. Curiously enough, these trees are hardy when carried far north of their natural range, growing well in Massachusetts. The nut is small and the shell thick, but Professor E. O. Wooton, of the Agricultural College of New Mexico, has sent me specimens from the Mogollon Mountains which are larger and thinner shelled than are most of the nuts of either species. It is possible that these may belong to *Juglans major* or to a species as yet undescribed. Consideration is given to the Texas and Arizona walnuts in these pages because the smaller tree, sometimes nothing more than a bush, may serve as grafting stock for dwarfing purposes in connection with other species of walnuts. If this works out practically, dwarf walnut trees of many kinds may be used for intercropping purposes with larger walnuts to advantage. Dwarf trees are prone to bear heavily and being small may be cut out as fast as they are encroached upon by the larger trees. Furthermore, these walnuts will grow in arid regions where there is very little rainfall. They may serve to carry valu-

able walnuts of other kinds into regions which are otherwise hopeless agriculturally.

JAPANESE WALNUTS

Botanists have suspected for a long time that the heart-shaped nut of the so-called *Juglans cordiformis* belonged to a varietal form of the common Japanese walnut, *Juglans Sieboldiana,* and that we are dealing with one species only when speaking of Japanese walnuts. Mr. E. H. Wilson, of the Arnold Arboretum, a botanical authority, states that, according to his observation, the Siebold walnut is the wild nut of Japan. It grows on the moist slopes and in the wet valleys from Hokkaido in the north to the mountains of Kyushu in the south. *J. cordiformis,* as he has observed it, is a cultivated form of the Siebold walnut and probably a sport from the wild tree. Nuts of the wild tree have been the ones imported into this country for the most part, and for that reason the hardy, rapidly growing, beautiful tree with foliage of almost tropical luxuriance has been held in low esteem for its nut crops. Recently the heartnut has been given attention by our orchardists. Heartnuts are more easily cracked and the kernels average larger in size than those of the wild Siebold walnut. The practical point of better cleavage of the heartnut will probably establish it as "the Japanese walnut" in this country. The Japanese walnut grows thriftily and bears precociously and heavily. In rich soil the leaves are sometimes a yard

in length. When the tree is in blossom with catkins of male flowers five or six inches in length and bright red spikes of female flowers glowing amidst the foliage we have a very beautiful object in the landscape, worthy of attention for beauty alone. The Japanese walnut, even as a seedling tree, may begin to bear when only five or six years of age. A number of hybrids between this species and our American butternut are already extant and the tree breeders are actively increasing the number of such walnut hybrids, with the promise that we shall have some remarkably good nuts coming out of this work in the next few years. The flavor of the kernel of the Japanese walnut is almost too gentle. On the other hand, some of our walnuts, like the black walnut and the butternut, have a flavor that is too pronounced for some palates. The merging of these different species by way of hybridization will doubtless give us varieties which will make a nice balance, their kernels possessing the most valuable qualities of different parents. The Japanese walnut may be grown farther north than any of our native walnuts, if we may judge from the fact that in its native country the tree is abundant in a climate which corresponds to that of Nova Scotia. While preferring a deep, rich, well drained soil this walnut adapts itself to soils which range from sand to clay. Walnuts of different species seem to lend themselves to grafting back and forth pretty readily, and the Japanese species is particularly friendly in this regard. Up to the present time I have not found any walnut

stock which would not accept the scions of any other walnut, yet there are differences in degree of hospitality. This family trait of fondness for relatives is extended into the hybridizing question, and the walnuts as a group seem to accept each other's pollen freely. Some of the cultivated varieties actually demand the presence of pollinizing neighbors, being more or less sterile to their own pollen.

One of the Asiatic walnuts, *Juglans mandschurica,* which is a nut resembling our butternut, but rather smaller and rougher, has been introduced into this country as a Japanese walnut, and another Oriental walnut, *J. sinensis,* has been imported also under the name *J. mandschurica,* leading to some confusion. There is a further tangle due to our more recent information that *J. sinensis,* which resembles the Persian walnut rather closely, is really nothing more than a northern strain of the latter species. The confusion in regard to the specific name, *mandschurica,* was due to the Yokohama Nursery Company making up that name for the *J. regia sinensis* of Decandolle, not knowing that the name had already been applied by botanists to another northern Asiatic species. It will simplify matters if we speak of *Juglans mandschurica* of the botanists as the Siberian walnut, and the *Juglans sinensis* as the Chinese walnut, and *Juglans Sieboldiana var. cordiformis* as the Japanese walnut, in our ordinary conversation about the dinner table. The confusion in relation to the name "Japanese" walnut will continue for some time. For ordinary purposes the common

names "Siebold walnut" and "heartnut" are discriminating enough, leaving out the word "Japanese" altogether.

The result of planting nuts from American grown Japanese walnuts threatened to disturb international relations at one time. Nurserymen sold young seedlings grown from such nuts as Japanese walnuts, but when the trees came into bearing they bore "butternuts"! Were the nurserymen dishonest? Perish the thought! They had planted nuts of the Japanese walnut growing in the vicinity of butternut trees, and there seems to be evidence that the Japanese walnuts frequently seize upon the pollen of the butternut in preference to their own, giving us hybrids, which have a tendency to show the characteristics of the butternut as a dominant factor. This particular observation will be interesting to the biologist in relation to the question of the descent of the butternut and the Japanese walnut. The butternut apparently represents the primitive type toward which newer types have a tendency to revert in accordance with organic law. The result of examination into this question at least cleared honorable dealers from the suspicion that they had been palming off butternut trees instead of Japanese walnuts upon their customers.

Grafted stock of choice varieties of the heartnut may now be obtained in quantity from dealers. The nut has not as yet become established in the market, being too new. Because of the beauty, hardiness, and early bearing of the tree it should be found in

every garden. When the market demands the nuts in carload lots these garden trees will then furnish scions for grafting upon wild walnut trees of other kinds. This tree along with the black walnut would appear to be particularly desirable for experimental planting in prairie lands of the west that have been worn out so far as grain crops are concerned. All of our nut trees belong in the same category for that matter, but the heartnut would seem to grow almost anywhere excepting in the far south and the far north. Trees of this species are smaller than the black walnut and are believed to be not so long lived. The early bearing would be suggestive of a shorter life, but we do not as yet know if this means fifty years or one hundred years for the full maturity of the tree. Two Japanese walnuts in good ground on my country property at Stamford were about thirty feet in height at eleven years of age, but others growing in glacial till were less than fifteen feet in height at the same age. For orchard purposes in good ground heartnuts may probably be set sixty feet apart to advantage.

CHAPTER III

HAZELS

HAZELS belong to a very ancient family, and some of the fossil hazel leaves are hardly to be distinguished from those of species which are living today. The American hazels comprise two species, *Corylus americana* and *Corylus cornuta*—the latter being called the "horn hazel," "beak hazel," "tail hazel," and other names referring to the shape of the involucre, which extends out into a prolongation beyond the apex of the nut. The quality of the kernel is inferior to that of the common American hazel. This latter species constitutes almost a weed and a nuisance in miles of old pasture, bearing a nut of good quality as a rule, but seldom large enough to be of value in the market. The shell is for the most part too thick to please any connoisseurs aside from jays, boys, and squirrels. Doubtless a number of thin-shelled, large-meated American hazels will be found eventually and I have two varieties which are being cultivated experimentally, because they are superior to the common hazel crowd out in the pasture.

AMERICAN HAZEL

The American hazel growing in bush form does not grow properly for economic development on its own roots. The habits of the species vary in different localities, but in Connecticut the central bush seldom bears nuts for more than seven or eight years with a good bearing period of not more than three years. The bush extends by sending long stolons underneath the ground in every direction, so that next to the central bush is a circle of bushes a year younger and so on to the margins of the patch. The hazel patches extend widely into the pastures in this way, central bushes dying out as younger ones arise full of ambition. The young bushes commonly bear a small crop of nuts in the third year, a very large crop in the fourth year and after that a rapidly dwindling crop so long as the bushes live. I have tried the experiment of cutting back stolons for the purpose of throwing all of the strength of the root into the original bush in order to make it live and bear for a longer period of time. Apparently about two years of extra life and bearing period were gained in this way, but the method was not practical, because Nature had made the hazel too "sot in its ways," or, to state the matter in another way, the protoplasm refuses to respond to stimulating hormones excepting for a period decreed by laws of evolution. Our next resource consisted in grafting the common American hazel of selected kinds upon the stocks of European and Asiatic

hazels. If the grafting is done at a distance of several inches above the ground no stolons are sent out. On these larger stocks and roots the common American hazel continues to bear heavily for a number of years in succession, but we do not as yet know how many years. Recently, I have grafted European hazels upon American hazel stocks in the pasture. These large tops required so much feeding from the roots that few stolons were sent out. At the present moment it appears to be possible to transform acres of worthless hazel patches into very valuable nut bearing orchards by grafting them to European varieties. When this is done we may graft to one healthy young stock in the hazel patch and cut off all of the surrounding bushes springing from the same root. There is one disadvantage in this method of propagation. The European hazel top develops into such a rapidly growing heavy bush that it will blow over or bend over from its own weight and injure the more slender American hazel stock near the ground unless we support each bush with a stout permanent stake of durable wood or metal. At the present time I have adopted the plan of grafting three American hazel stocks in one clump and then fastening the bushes together, subsequently tying a few branches with tarred sisal cord. This tripod stock arrangement may avoid the necessity for artificial support. The outlook for transforming our worthless pasture hazels into valuable income producers appears to be hopeful at least.

HORN HAZEL

The horn hazel nut, while not of as good quality as that of the common American hazel, may give us something valuable in its hybrids. We may find ourselves using horn hazel stocks or hybrids made with the species for extending the range of valuable varieties far northward. I have found this hazel extending pretty well up in Labrador and in the Hudson Bay basin nearly to James Bay. The bush grows to a large size in the far north. In fact, it is difficult in that latitude to distinguish this hazel from the American elm at first glance. The elm stunted to smaller size and the hazel growing to larger size brings the two species to similar dimensions, and I have found myself looking for hazel nuts in an elm tree in some of the thickets about Flying Post. On the Pacific coast the horn hazel sometimes grows to a height of thirty feet, and on that account was at one time held by some botanists to represent a different species.

The hazels appear to accept each other as readily as the walnuts do for grafting purposes within the family.

OTHER HAZELS

The Asiatic tree hazel, *Corylus colurna,* seems to offer great advantage as grafting stock for various other hazels, because it sends out no stolons and grows to become a large tree. Another Asiatic

tree hazel, *Corylus chinensis,* occasionally reaches a height of one hundred feet. Judging from the latitude of its indigenous origin one would not anticipate hardiness in the colurna tree hazels in the north, but they appear to be perfectly hardy in Connecticut, and as yet the colurna has shown no tendency to blight. I have not experimented with the Chinese hazel. The hardiness and blight resistance of the colurna tree hazel may be due to the fact that its thick corky bark acts as a protector. When grafting other varieties and species upon the colurna tree hazel it is necessary to remove some of the thick corky bark in order to allow the wrappings of the graft to hold. This leaves an area of tender bark exposed, and we must keep it covered with paraffin for a year. At the end of that time a new spongy corky layer has been developed. Judging from my experience to date in using the large tree hazels as grafting stocks for bush hazels the idea is to work out practically in an advantageous way.

Two Oriental species, the Jacquemont and the Chinese hazel, grow to the height of our larger oaks. They may push European hazels up to nearly that height when top-worked. Hybrids may perhaps be grown which will combine the grandeur of the tree hazel with enormous crops of nuts, large in size and carrying European hazel quality.

The colurna tree hazel bears its nuts in pendant clusters "as big as a fist." The nuts themselves are not larger or more valuable than the nuts of the common American hazel. I have made some hybrids

between this and other species, but the hybrids are not as yet in bearing. It may be that we shall eventually have hybrid trees carrying the very large cluster characteristics of the tree hazel with nuts of the size and quality belonging to the best European varieties. The common European hazels, *C. avellana, C. maxima,* and *C. pontica,* in their many varieties stand midway between the American hazels and the Asiatic tree hazels in size, the bushes commonly growing to a height of fifteen feet in the east. In the rich land of Oregon they nearly double this size and become trees with trunks two or three feet in circumference. Nuts of many of the varieties of the European hazels command a high price both as dried nuts and when sent to market in their green husks. In some parts of Europe and in the Mediterranean region hazel orchards furnish an important income for large districts. The European hazels send out few stolons from the root, but there is an allied phenomenon, the sending out of vigorous new shoots from the trunk, crowding out the older branches. The hazel orchardist trims out the older branches from time to time, giving the newer growth its opportunity and finding it more fruitful than the older branches, because the old wood like that of the American hazel has a limited number of years of fruitfulness.

Hazel nuts as large as hickory nuts are now arriving from Oregon orchards. The foreign hazel bearing the largest nuts is the Pontine species, *C. pontica,* but the shell is thick and on that account it has not

furnished many varieties for importation into this country. It is a species, however, with which our plant breeders may work successfully with the object of attaining size of nut, if that is desirable. Some of my own hybrids between this and the American hazel have small nuts.

A number of species of European and Asiatic hazels are cultivated extensively but without possessing characteristics which are remarkable beyond those mentioned in these notes. The cultivation of foreign hazels in America made slow progress for many years, although nuts were planted and nurseries sent out seedling trees and layered stocks of fine varieties to their customers. The reason for this late development of the European hazel was due to its vulnerability to the common hazel blight, *Cryptosporella anomala.* This blight attacks the trunk as well as the smaller limbs of the introduced hazels. It belongs to our common American hazel and does little harm when growing upon that species, its attacks being limited chiefly to bushes which have been injured in some way. This doubtless presents a parallel history to that of the Chinese chestnut with its fungous parasite *Endothia.* Where host and pest have developed side by side for ages the host, by natural selection or by development of resistance, does not allow the balance of nature to be disturbed. The pest, however, when attacking species which have not developed protection by way of natural selection or by the development of resistance does allow the balance of nature to be disturbed. The

hazel blight, fortunately, extends its ravages slowly. It wiped out the earlier introduction of foreign hazels, because it was overlooked until it had completely girdled limbs or trunks. Two years or more are often required for *Cryptosporella* to girdle a limb or a trunk of a hazel. If we go over the orchard once a year, cutting out blighted bark and protecting the exposed area, it is a comparatively simple matter to manage this pest. When it appears in the phase of an enemy of smaller twigs only one or two twigs are attacked as a rule in the first year. If one is on guard, control of the hazel blight becomes one of the minor cares of the orchardist. If one is careless the blight will be attentive.

There is some confusion in connection with the word "filbert" as applied to some of the European hazels. The word hazel comes from the Anglo-Saxon *haesel,* meaning a hood, but in the varieties which have an involucre extending beyond the apex of the nut, the term filbert, a corruption of "full beard," is applied. When the dried nuts are sent to market no one knows whether the involucre was long or short unless he happens to know the variety. On that account the term filbert cannot stand for all European hazels, and confusion arises. Eventually, as the public becomes better educated, distinction will be made as it is with apples in calling for named varieties of hazels. The name filbert should then pass out of common usage as a general name for hazels. Fresh hazels are so highly prized in Europe that very high prices are secured for

good kinds sent to market in the husk when the husk first takes on the tinge of ripening. In New York markets fresh hazels were sold for prices as high as seventy-five cents a pound before the time of war prices. The market for fresh hazels, however, is probably a comparatively limited one, while the market for the fully ripe nuts and the hazel oils is practically unlimited.

Hazels as a group are not so particular about soils as are some of the walnuts, standing perhaps midway between the walnuts and hickories in this regard. If hazels are planted in a soil which is too rich and moist they have a tendency to produce very large woody growth at the expense of nut production. On the other hand, in poor and thin soil they grow slowly and bear small nuts even when prolific. As a rule they prefer soil neutral in reaction, although the common American hazels will thrive pretty well in soil that is distinctly acid. Well drained loam gives the favorite soil texture for the hazels, but they manage to get on pretty well in sandy soils and in some of the clay soils. On the northern Pacific coast hazels have found their best home up to the present time in North America.

Hazels of varieties which do not exceed fifteen feet in height need not be set more than fifteen feet apart in the orchard. Larger kinds will have to be set at distances appropriate to their dimensions, but above all is to be remembered the fact that hazels need company for cross pollination. It is essential

to have more than one variety, preferably several varieties in any one orchard.

One important function of the hazels will relate to their value as fillers in orchard planting of nut trees. If the black walnut, the Persian walnut, and the pecan hickory, for example, are to be set one hundred feet apart, a good many years will be required for the filling of unoccupied space. Orchardists sometimes try to split the difference by setting large kinds of trees fifty feet apart with the intention of cutting out every other tree when the limbs touch. Hazels as intercrop trees may be cut out one by one as the space is required without much loss because of their comparatively small size.

CHAPTER IV

CHESTNUTS

AMONG the chestnut trees in our country the American chestnut, *Castanea dentata,* is the largest. The chinkapin occurs in two forms. *Castanea pumila* is a bush seldom growing more than fifteen feet in height in its eastern range, but west of the Mississippi it occurs in tree form, *Castanea pumila arboriformis,* the tree in favorable soil reaching a height of sixty feet. *Castanea alnifolia,* the alderleaf chestnut, is a shrub which sometimes assumes a trailing form. Another form in some localities makes a tree forty feet high. It belongs to our southwest in open pine woods, but is fairly hardy as far north as Massachusetts. The chestnuts which have been introduced into this country are the Japanese chestnut, *C. crenata;* the European chestnut, *C. sativa,* and the Chinese chestnut, *C. mollissima.*

Allied to the chestnut we have two species of the evergreen Castanopsis of the Pacific slope.

AMERICAN CHESTNUT

Our magnificent American chestnut forests are now being wiped out by the blight *Endothia para-*

sitica and the entire species may disappear unless resistant individual trees are found or unless the blight loses virulence. We may anticipate, however, that such may be the case and here and there a tree is now being reported as blight resistant. Bleaching stark skeletons, however, of the formerly beautiful chestnut trees now fill the forest which such a short time ago gladdened the early July landscape with their heavy masses of sweet scented flowers and in autumn tempted children, both young and full grown, into the woods for the delicious nuts. On my own property at Merribrooke there was one chestnut tree which bore particularly large nuts of high quality and the nut had a peculiar beauty because of its coloring, alternate stripes of light and dark chestnut color. This particular tree was one of the first to go down with the blight, but I have now kept it going for ten years by grafting it upon chinkapin stocks, hoping to hold on to the variety until the blight loses its vital energy or is attacked by some parasite of its own. The grafted tops of this "Merribrooke" variety blight and die back, but by making new grafts every year I am still in possession of this particular chestnut. Here and there about the country are isolated groups of American chestnuts growing out of their indigenous range, and these trees may preserve the species for many years if blight does not reach them by way of nursery stock planted in the vicinity.

CHINKAPIN

I have made a large number of hybrids between the American chestnut and the chinkapin which is highly resistant to the blight, and some of the hybrids carry the resistant quality of the chinkapin parent while bearing nuts of good size and high quality. Hybrids which show the chinkapin parent in the tree most distinctly have resisted the blight best, while those which show the American chestnut characteristics markedly are more vulnerable to the blight. Most of the hybrids bear nuts which do not possess much value, but three of the best hybrids have been presented to nut nurserymen who will keep them in stock. None of the hybrids so far have shown a tendency to make valuable timber of the sort belonging to the American parent. The chinkapin, while not wholly immune to the blight, resists it so well that trees may bear heavily for many years, making it worth while to include hybrid kinds in nut orchards. Blighted limbs must be trimmed out from time to time. The chinkapin illustrates one of Nature's ways for checking the distribution of a species. It has a habit of sprouting its nuts as soon as they have fallen in the autumn. In the south the new growth becomes sufficiently well lignified to withstand the winter. In the north this is not the case. The chinkapin then would naturally be limited to areas in which autumn sprouting of nuts could make good winter wood. The tree itself, however, is hardy after its first year of age.

Transplanted northward, it thrives as far north as Massachusetts. It may be hardy north of that, but I have no records. Chinkapin hybrids bear precociously and in very great abundance and will serve very nicely for intercropping between trees of large and more valuable kinds of nuts, while the latter are growing and getting into bearing age. In the south the chinkapin is attacked so freely by the nut weevils that few nuts are found without larvæ. Where the wild trees are abundant in their native region it would seem almost hopeless to dispose of the weevil nuisance. In the north, however, the weevils have not as yet found my chinkapins.

EUROPEAN CHESTNUT

The European chestnut blights so readily that we may as well not attempt to do very much with this tree at the present time. The nuts, while large, are of inferior flavor, although valuable for food purposes when cooked. Some of the nut orchardists living out of the range of the blight have developed chestnuts of European kinds which are desirable.

JAPANESE CHESTNUT

The Japanese chestnut bears a very coarse nut with little flavor. It furnishes an important food supply in its native country, where the nut practically takes the place of the potato in some of the mountain regions. The tree does not blight quite as readily as

does the American chestnut, but needs constant attention, usually failing before many crops have been borne.

CHINESE CHESTNUT

The Chinese chestnut, a very beautiful tree, is in my experience the most resistant of the introduced species. It comes from the original home of the blight, and as a result of natural selection we might anticipate that this would be the most resistant species, representing survival of the fittest. The Chinese chestnut makes a beautiful lawn tree with its glossy foliage and its heavy masses of burrs. Its nuts are less coarse than those of the European chestnuts, although not quite close rivals of the native American chestnut on the score of quality.

ALDERLEAF CHESTNUT

The alderleaf chestnut is one of the most beautiful of shrubs, particularly in the trailing form which sometimes occurs. It is evergreen in Georgia. When growing at Stamford, Connecticut, it loses most of its leaves in winter, although I have sometimes found an occasional green leaf in spring, one that had been buried beneath the snow or protected by autumn leaves. The nut is not large enough to have much market value, but none of the bushes of this species on my grounds have shown any blight at all as yet, and we may use the alderleaf chestnut profitably perhaps for hybridization purposes.

CASTANOPSIS

The Castanopsis, or golden chinkapin, is an evergreen tree from the Pacific coast. It has been transplanted experimentally in the east, but it does not thrive in the eastern climate of North America. It occurs in two forms, perhaps with specific differences—the larger form sometimes giving a tree one hundred and fifty feet in height with a diameter of ten feet. The nuts, while very small, are delicious, but too tiny for market purposes. The smaller species is sometimes little more than a shrub. It grows at such an elevation on Mt. Shasta in California that it must be subjected to winter conditions similar to those of the northeast. It may be that the smaller form secured from the Mt. Shasta region may be made to grow eventually in the northeast.

Our best outlook for the chestnut in this country at the present time includes the idea of developing valuable blight-resistant hybrids or of establishing chestnut orchards in prairie regions where they would remain isolated from blight areas. The chestnut market is such an important one and so well established that it should be maintained in some way. Mr. E. A. Riehl, of Godfrey, Illinois, has given attention to this question and has developed several varieties of chestnuts in his orchards which are out of the blight region. Fourteen dollars per bushel has been obtained for the nuts of some of these varieties. The trees bear precociously and so well that I asked Mr. Riehl for a report indicating prospects

for other growers who might follow his example. His letter dated October 26th, 1920, states the case briefly but authoritatively:

"In reply to your letter asking for the estimate of crop on chestnut trees, the following is the record of the original Boone tree:

1896—Seed planted in spring.
1897—Produced six burrs averaging two and three nuts.
1898—Produced one pound of nuts.
1899—Produced three pounds of nuts.
1900—Produced five pounds of nuts.
1901—Produced six pounds of nuts.
1902—Produced eight pounds of nuts.
1903—Produced twelve pounds of nuts.
1904—Produced seventeen pounds of nuts.
1905—Produced twenty-five pounds of nuts.
1906—Produced thirty-one pounds of nuts.
1907—Produced forty-three pounds of nuts.
1908—Produced fifty pounds of nuts.
1909—Produced fifty-six pounds of nuts.
1910—Produced five (hard freeze while in bloom).
1911—Produced eighty pounds of nuts.
1912—Produced seventy-six pounds of nuts.
1913—Produced one hundred twenty-five pounds.

"Later than that I have no definite record, but my information is that it is now producing from one hundred and fifty to two hundred pounds annually.

"This is an extreme performance and will not do

as a basis for general use. This seed was planted in rich garden soil and never transplanted. Also this variety comes into bearing earlier than others.

"From my own experience with my varieties, I think it would be safe to place the estimated crop at ten pounds per tree at ten years of age, increasing annually from five to ten pounds. I have trees that produced sixty pounds at twelve years after planting.

"I have just completed marketing this season's crop, which was the largest yet. Prices somewhat less than last season, yet quite satisfactory. My crop will increase steadily from now on as trees get larger and younger ones come into bearing."

The Boone chestnut belongs in the group that is to be cooked before being eaten. In my experimental work the tree is blight resistant to a notable degree.

At the time of present writing nurserymen cannot send chestnut stock from a blight state into any other state. This measure aimed at control of the blight has been a wise one within its limitations and has protected orchards like those of Mr. Riehl. If the law is modified in such a way as to allow chestnut stock to be shipped from one blight state into another blight state it will allow of wide distribution of resistant hybrid chestnut stock to public advantage.

Chestnuts of different species are grafted easily upon stock of the right sort, but they are not so readily interchangeable as are the walnuts and hazels. In my experience the American sweet chestnut is not accepted kindly by either the Chinese or Japanese

chestnuts, although it is accepted by the chinkapin. The European chestnuts appear to grow better upon American chestnut stocks than they do upon those of foreign species. A Chinese chestnut that I cut back and top-worked with scions of an American sweet chestnut and also with scions of a hybrid between the American chestnut and the chinkapin allowed both kinds of scions to grow thriftily during that summer. In the following winter the American scion growth all died but the hybrid scion growth lived—both kinds being equally hardy so far as climate is concerned. The difference in result evidently represented stock influence. Some of the chestnuts may perhaps be grafted upon some of the oaks. In my own experience the American chestnut was accepted fairly well by the red oak, but absolutely refused by several other kinds of oaks. A variety of European chestnut was accepted by the water oak, which had refused the American chestnut. This particular feature of experimental work is too speculative to call for extended reference in these pages beyond the mere making of a suggestion.

Orchardists are recovering from the effect of the first shock that was given by the chestnut blight and they are now ready to go ahead with hybrids and with orchards situated at a distance from blight regions and out of the line of flight of migratory birds which carry blight spores upon their feet and in their feathers. The most profitable chestnuts for American orchardists will probably be those of the sort which are to be cooked rather than the more

delicately flavored ones which are eaten out of hand. One kind of chestnut flour bread used in southern Europe has large holes like those of Swiss cheese. Extra lumps of sweet butter fit nicely in these holes. A slice of almond cake placed between two slices of chestnut bread makes a delicious sandwich. Chestnuts raw or cooked in various ways constitute an important food for live stock and fowls.

CHAPTER V

PINES

VARIOUS species of pines and allied cone bearing trees are to take their place more and more in the nut tree group, adding their peculiar beauty to the feature of utility. A pine tree brings a momentary glow of pleasure whenever we catch it in a passing glance at any time of the year, but especially in the winter. Emerson says that water is to the landscape what the eye is to the face. The pine tree is to the landscape what a pleasant smile is to the face of a friend. If the utilitarian who would raise fruit and nut trees for profit were to be obliged to leave out all of the pines it would be an unkind reservation on the part of Nature. In winter the brave green of the pine dominates a snowy landscape. Strong and serene, it stands bright with life when autumn winds are whirling the leaves of other trees into the litter of a departing season. In the summer a hot sun brings forth from the pine a fragrance to be added to the cool shade beneath its branches. Among the trees of the world the palms with their many kinds of coconuts probably stand first in order for nut food supply furnished to man. After these perhaps

come the various species of nut bearing pines and allied cone bearing trees. The chestnuts may rank third so far as nut tree food supply for various peoples is concerned. Statistics are not available, because the people who use pine nuts extensively depend upon them for home use and not for market purposes. Most of the pine nuts belong to the sweet and oily group with high protein content, but the Araucarias with their large, starchy nuts furnish carbohydrate food for peoples of the southern hemisphere of both continents and in Australia. Like potatoes or peanuts the Araucaria nuts are not good until cooked. Nuts of the Bunya Bunya pine are about the size of the average Persian walnut, and from that size downward pine nuts occur in various shapes and sizes until we come to the smaller kinds—some of those which are used for food not being any larger than grains of buckwheat. The smaller ones are sometimes eaten shell and all. Pine nuts of the oily group are sometimes very highly flavored, sweet and delicious—some of the pignolias and piñons taking high rank for quality. Pine nuts of the starchy group are commonly roasted or boiled before being eaten, while those of the oily group are sometimes roasted, although most of them are more delicious when eaten raw out of hand. Another way for preparing pine nuts of the oily group consists in covering them with a little water and squeezing out the contents with a press. The thick milky residue being subjected to partial evaporation will keep for a long time and may practically take the

place of meat. The cake that is left after pressing has value as food for stock and fowls.

The conifers possess one particular advantage in the fact that they seem to require no cultivation at all. Many of them are lovers of mountain sides and of rough land and may be grown where other fruit trees would not thrive, or at least could not be raised profitably.

Pines, like other nut trees to be used for fruiting purposes, should be set far enough apart so that the trees may have full sunlight and little competition from other pines, otherwise they will go on to make timber trees and not be very fruitful. Conifers, as a group, are more exacting than are some other kinds of nut trees in relation to soil and climate, each species being inclined to grow in pure stand in localities of its own choice. Nut bearing conifers for the most part belong to warmer parts of the world. Some which are hardy enough when transplanted to the latitude of New York grow slowly. The sugar pine, *Pinus Lambertiana,* for example, one of the most magnificent of forest trees in the west, with rich sugary and oily nuts, furnishing also a solid sugar from its evaporated sap, becomes homesick in the east. It has not fruited to my knowledge here and grows very slowly. The common piñon, *Pinus edulis,* has sometimes made not more than one or two inches' growth in a year on my country place, and the same is true of the Torrey pine, *Pinus Torreyana.* The Jeffrey Bull pine, *Pinus Jeffreyi,* is one of the most beautiful pines in my collection and

grows thriftily but has not fruited as yet. The Korean pine, *Pinus koraensis,* and the Sabin pine, *Pinus Sabiniana,* seem quite at home in Connecticut and so do the Swiss and Italian stone pines, *Pinus cembra* and *Pinus pinea,* although the latter needs a warm side hill and some degree of wind break protection. The Armand pine, *Pinus Armandi, Pinus Bungeana,* and *Pinus parviflora* are all hardy nut pines, and grow well in the vicinity of New York, but we do not as yet know their fruiting values in this part of the country. There are perhaps thirty different species of conifers of the nut bearing group which are to be tried out more extensively between Quebec and Florida. The seeds of all of these pines may be obtained through dealers and Mr. Thomas J. Lane, of Dresher, Pennsylvania, at my request, has made a feature of obtaining pine seed for experimental purposes. For ordinary eating purposes at present several kinds of pine nuts going by the general name of piñon may be bought in hundred-pound lots from dealers in the southwest. The firm of Vilmorin, Andrieux et Cie, of Metz, Alsace, is a European firm that will furnish nut seeds or seedling trees of anything to be obtained in Europe. The Yokohama Nursery Company, of Yokohama, Japan, will obtain almost any Asiatic species.

I wrote Mr. D. Hill, of Dundee, Illinois, a specialist in the growing of pine trees, asking if he would interest himself in furnishing nut bearing species. Mr. Hill replied that at one time the idea

had come to him independently, and he put in a stock of several kinds of nut bearing pines. There was no call for them and he dropped them out, but was giving the matter further consideration. Mr. Hill would doubtless be glad to render service if encouraged by advance orders. Young pine seedlings in the nursery require expert attention, and the amateur may best buy trees not less than three years of age.

CHAPTER VI

THE BEECH

THE beech tree, *Fagus,* belongs to a genus containing more than a dozen species of trees, some of them being deciduous and others evergreen, widely distributed throughout the temperate regions of both hemispheres. The common beech of North America and of northern Europe are closely related and are the two species which are at the present time most valuable for their food products. The nuts, while small, are borne so abundantly that animals and birds become very fat upon this mast. The nuts for the most part do not find their way into the markets as food for man as yet.

In all probability trees bearing specially large nuts will be selected for purposes of propagation and perhaps under conditions of cultivation a large beechnut for table use will be developed. Among many parcels of beechnuts sent in response to prize offers there has been an occasional lot of nuts so much larger than the average that we may anticipate the finding of larger ones yet when a sufficient degree of attention has been given to the subject.

As yet grafting of the beech has been done only for the securing of ornamental types.

Although the beeches of North America thrive best in limestone regions we find large beech forests on soil that is more or less acid in reaction. In these soils beech trees, while bearing large crops of nuts, usually do not fill out the kernel well, and for that reason it is only when conditions are particularly favorable that one may obtain even a handful of beechnuts large enough and well enough filled for eating. When we have developed some tree bearing particularly large beechnuts we may perhaps be enabled to secure full meated nuts in acid soil regions by adding lime to the soil. Our American beech, *Fagus ferruginea,* comes into bearing very late as a seedling tree, sometimes not before its thirtieth year, but in all probability grafted varieties will give us the history of grafted varieties of other nut trees in relation to precocious bearing.

Even when the nuts are too small for eating out of hand they may be collected in quantities and the oil expressed, as has been done in European countries. Beechnut oil is valuable for cooking purposes and as a salad oil. In some parts of Europe it is used in place of butter. The cakes which remain after the oil is pressed out serve as food for stock and fowls. In this country we have not as yet reached the point where the collection of beechnuts for this purpose is profitable, but in many localities live stock and fowls are allowed to do their own collecting so profitably that little or no corn is required for their fattening. We may look forward to the time when the development of the beech will be an important feature of nut growing.

CHAPTER VII

THE OAKS

Acorns of many species of oaks, which furnish food for man as well as beast, are already used in many parts of the Old World, and the Indians in this country crushed acorns, which required removal of tannin by washing, making the meal into bread, mush and cakes. John Muir in his difficult mountain climbing in California found the hard acorn cakes of the Indians the most compact and strength giving food to be carried on exploration trips. The white oak group furnishes the larger number of species with sweet acorns eaten by man in North and South America. Enormous crops of nuts are borne by some of these trees, and development of the acorn as a starchy food supply for man and his domestic animals will belong to our new work.

CHAPTER VIII

THE ALMOND

THE almond, *Amygdalus,* is so closely related to the peach that some botanists believe the latter to represent an offshoot from the wild almond by cultivation and selection rather than a separate species of tree. Almond nuts are nitrogenous nuggets of such value that the extension of almond culture in this country is certain to be profitable. At the present time the tree is grown in a large way on the Pacific slope only. Varieties with soft-shelled nuts were developed in warm parts of the Old World, and consequently are not hardy very far north. Some of the hard-shelled varieties will probably be found to range quite as far north as the peach. The almond as a drupe is like the peach, but the soft part of the fruit in the almond constitutes little more than a thick skin. The beauty of an almond tree when in flower has led to its introduction as an ornamental tree in the form of varieties which are not particularly valuable for their nuts. Early blossoming of the almond exposes it in the north to the danger of late spring frosts. As one of the oldest of cultivated nut trees it demands, like the peach, a good deal of

skilled attention. If this is not given, the almond tree quickly begins to look unthrifty and becomes vulnerable to many fungous, bacterial and insect pests.

The propagation of the almond, like that of the peach, is by bud and scion grafting. In fact, almond grafting was highly successful in California and in our southern states long in advance of the time when other nut trees responded favorably to our efforts. The almond, while enjoying rich ground and abundant rain as a rule, presents varieties belonging to arid regions. These varieties will thrive under conditions not suitable for any of our other nut trees so far as I know, excepting the Texas and Arizona walnuts. Because of this fact we shall eventually find large areas suitable for special kinds of almond culture. A very large number of seedling almonds now being raised in this country may allow us to develop better kinds than any which have been developed previously and with larger adaptation to soil and climatic conditions. No tree of the nut tree group is more exacting than the almond in its demand for just the right condition of soil and climate, but the many varieties will find soils to their individual liking.

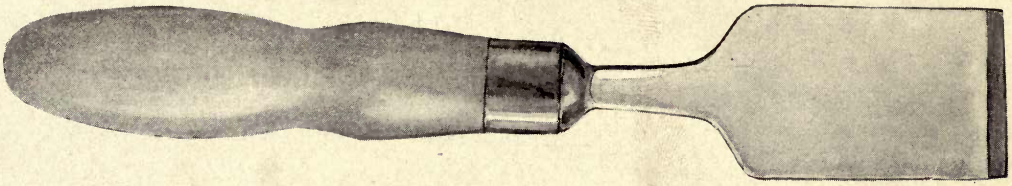
The bitter almond as a varietal type contains prussic acid in excess, but some of the nuts find their way to market for flavoring purposes.

The quality of hard-shelled almonds may be higher than that of soft-shelled kinds, but for ordinary market purposes soft-shelled almonds return best profit on the investment.

This matter of quality is of minor importance when we are dealing with a nut of such high food value. We may never be able to raise almonds in this country which will compete for dessert and confectionery purposes with those from the original home of the tree. So long as we raise carloads of delicious food, however, the dessert question will remain one relating to flavor and a small part of the market. Almond products are rapidly taking a place in the food ration in many forms. The California Almond Growers' Exchange, under the management of Mr. T. C. Tucker, has aligned the almond market with that of the California Walnut Growers' Exchange and the National Pecan Growers' Exchange.

In experimental work at Stamford, Connecticut, hard-shell almonds have been so vulnerable to scale and blight and borers as to hardly merit the attention demanded, although they bore heavily. A variety of soft-shell almond of very high quality which I obtained from a missionary in Syria grew with remarkable thriftiness through two summers and survived one hard winter without injury of any sort. In the second winter, however, with less cold weather the tree died. The fact of this variety living through one winter and two summers indicates that varieties of almonds with soft-shelled nuts may be grown pretty well in the north eventually.

The peculiar charm of nut growing belongs to just this feature of unknown possibilities—calling out the spirit of the pioneer who is to do something for the people of to-morrow.



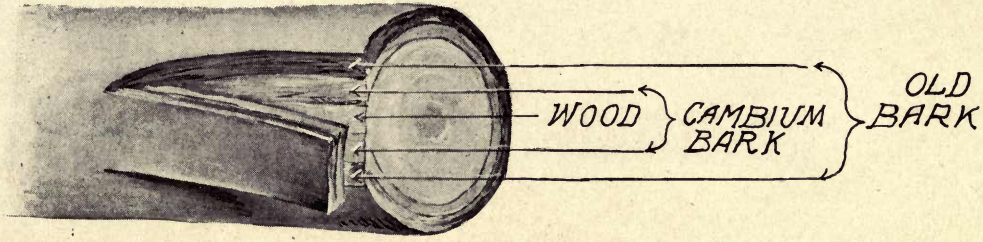


FIGURE 1.—Knife and chisel for nut tree grafting work.
FIGURE 2.—The vital cambium layer of bark.

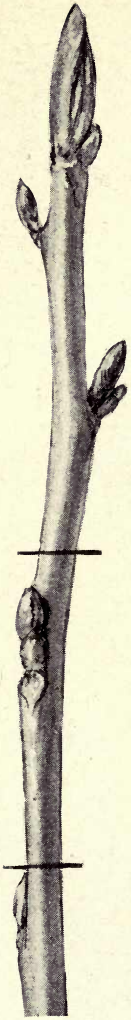


FIGURE 3
Division of bud stick into scion lengths.

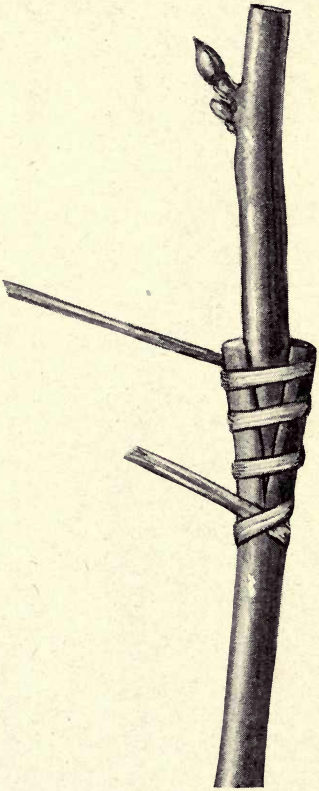


FIGURE 5
Ordinary cleft graft with full wedge scion.

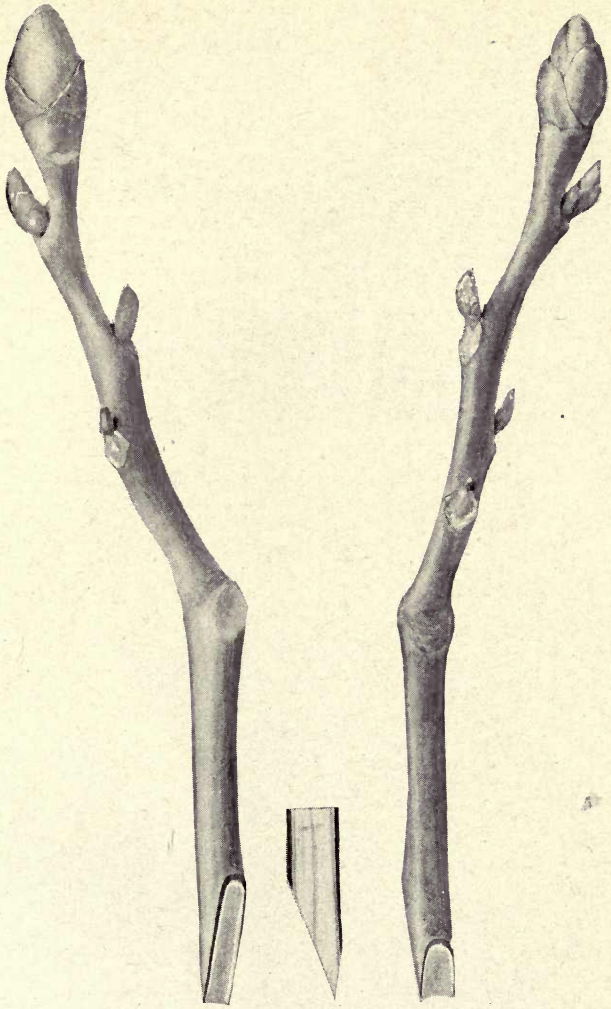


FIGURE 4
Scion shaped for bark slot graft in modified wedge form.

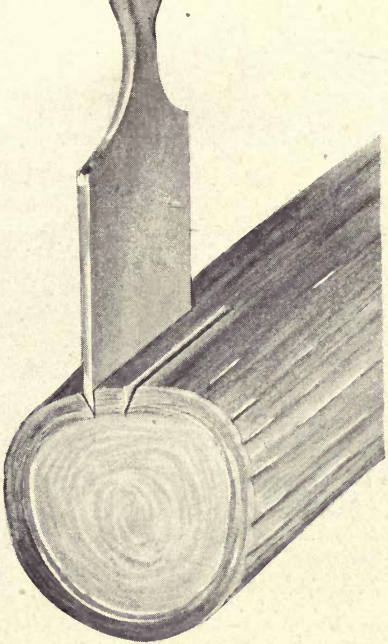


FIGURE 6

Cutting the bark slot for a distal graft in a large hickory limb.

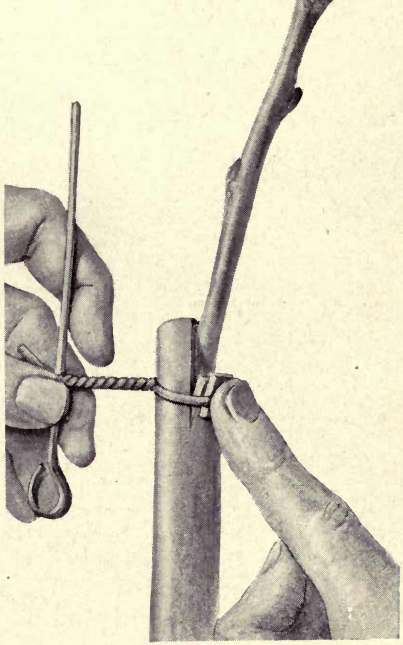


FIGURE 7

Adjusting Spanish windlass to distal bark slot graft. Small wooden shield protects bark against injury.

(This is the nicked splice graft if raffia binding is employed.)

FIGURE 8

Applying melted paraffin to a distal bark slot graft.

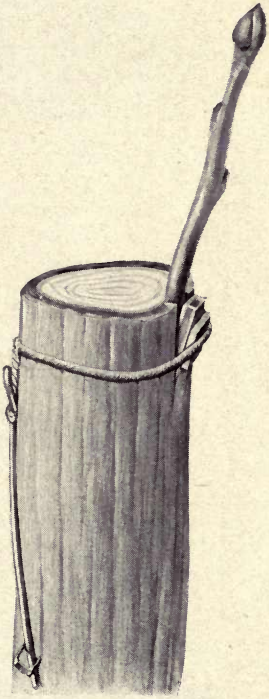


FIGURE 11

Spanish windlass adjusted to distal bark slot graft.

Twister held in place with staple driven into bark.

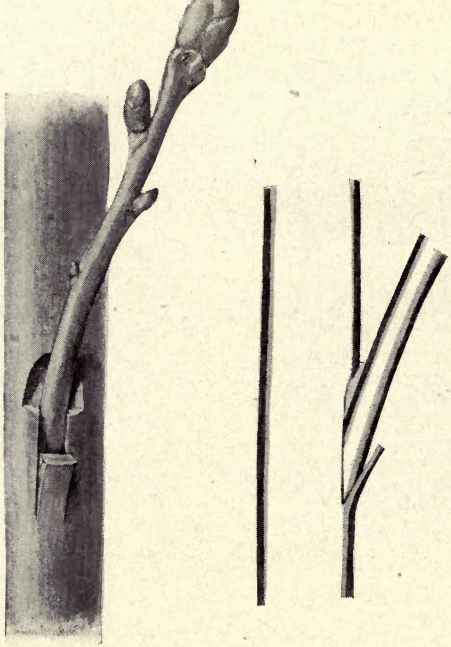


FIGURE 9
Scion inserted in proximal bark slot ready for fastening and for paraffin coat.

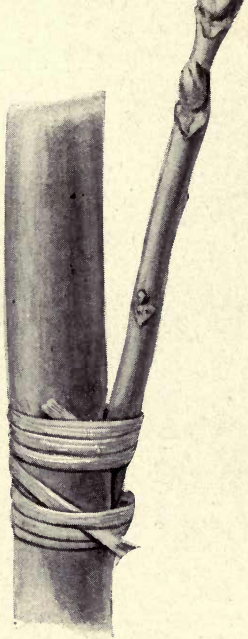


FIGURE 10
Proximal bark slot graft in small limb fastened with raffia. Ready for paraffin coating.

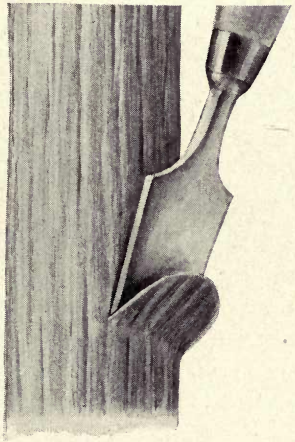


FIGURE 12
First incision for proximal bark slot graft in large hickory limb or trunk.

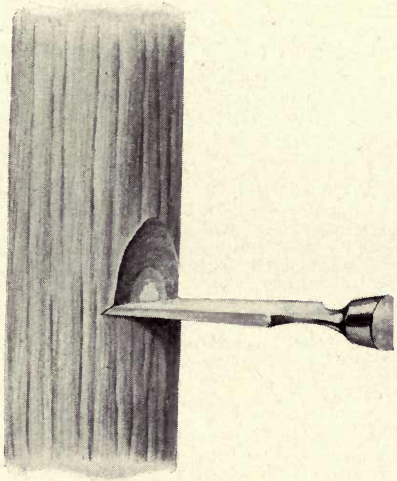


FIGURE 13
Second incision for bark slot graft in large hickory limb or trunk.

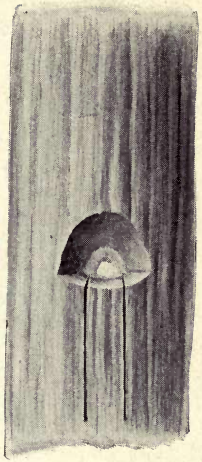


FIGURE 14
Third step in cutting bark slot.

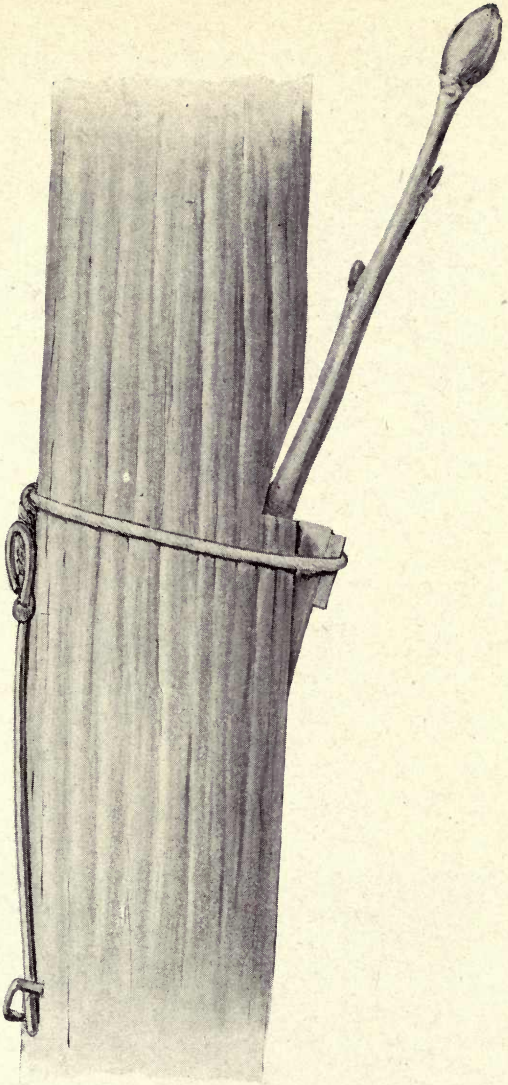


FIGURE 15

Proximal bark slot graft in trunk of tree, fastened with Spanish windlass. Ready for paraffin coating.

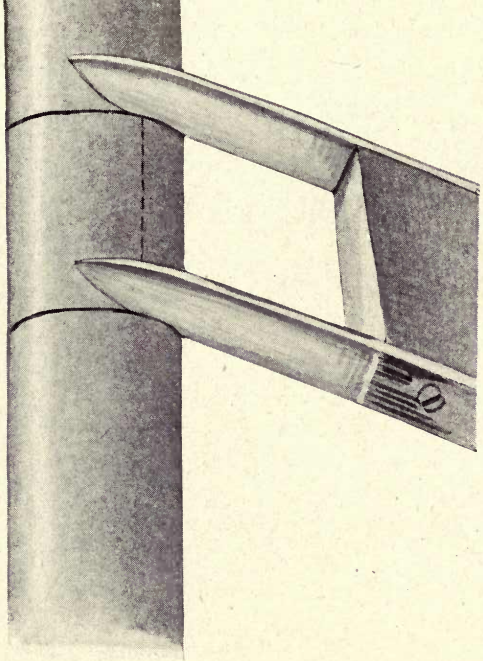


FIGURE 16

Cutting ring of bark with double bladed knife for Rush graft.

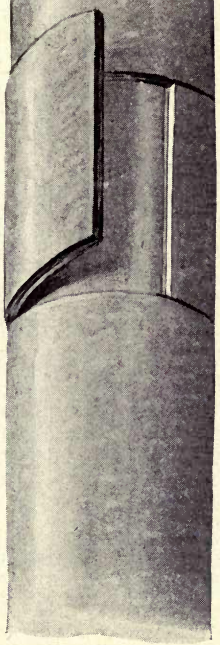


FIGURE 17

Ring of bark lifted for insertion of bud cut with the same double bladed knife.

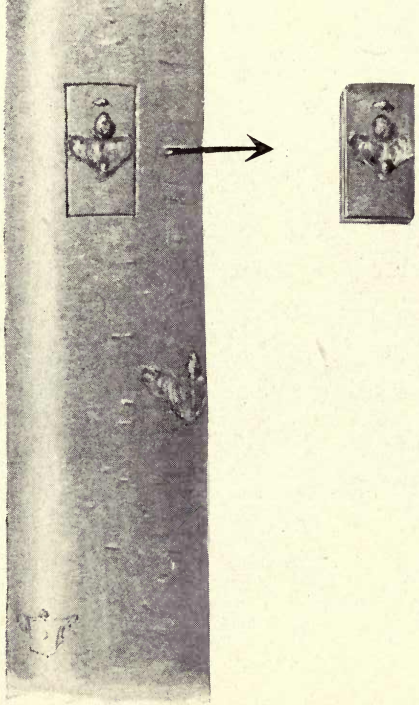


FIGURE 18

Patch bud graft cut with the Jones cutter.

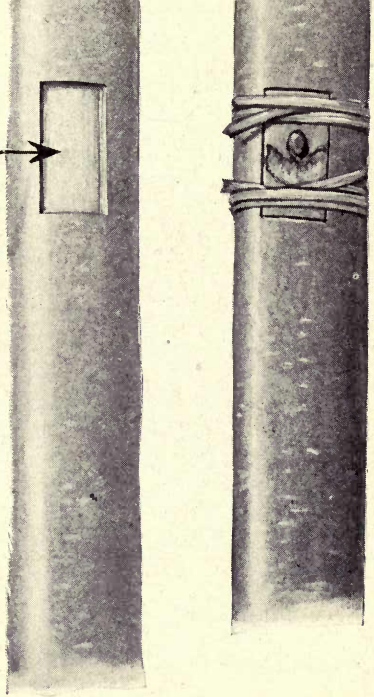


FIGURE 19

Patch bud graft fastened with raffia. Ready for paraffin coating.

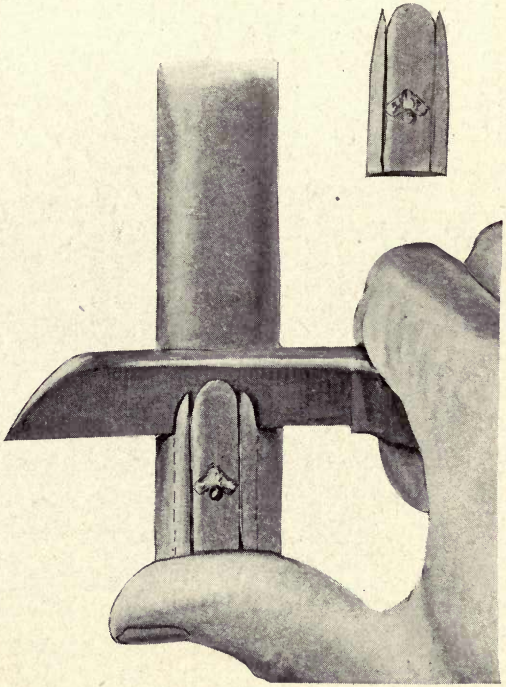


FIGURE 20

Chip bud from thick barked tree for distal or proximal bud grafting.

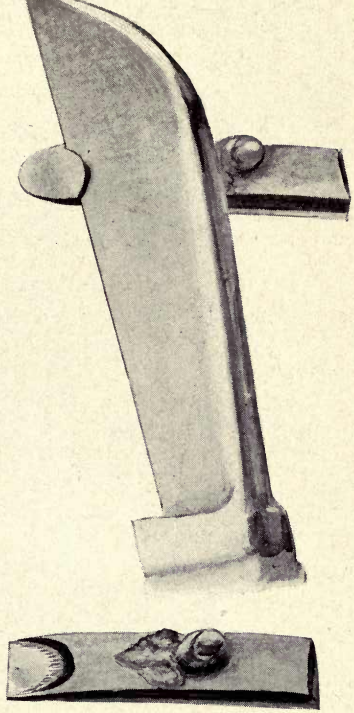


FIGURE 21

Shaping the bud graft for insertion into a bark slot.

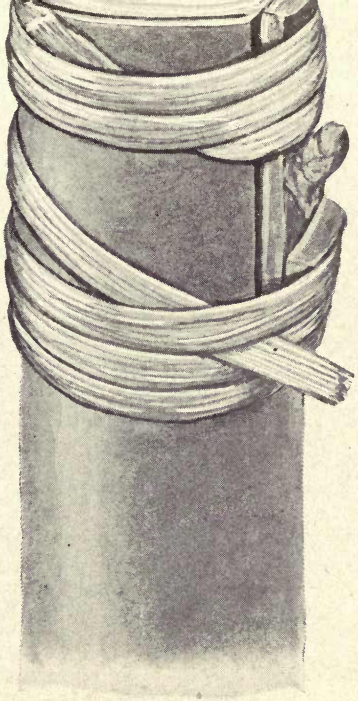


FIGURE 22
Chip bud, distal graft held in place with raffia.

FIGURE 23
Chip bud—distal graft paraffined.

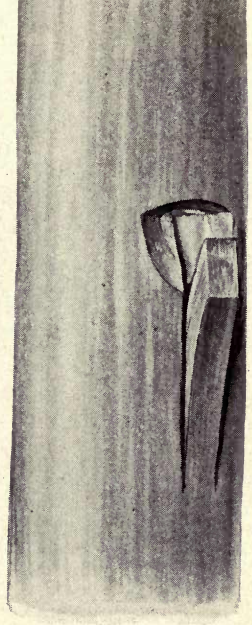


FIGURE 24

Tongue of bark pried loose. To be cut shorter for insertion of proximal chip bud graft — in thick barked tree.

FIGURE 25

Chip bud graft from thick barked tree, shaped ready for insertion in bark slot.

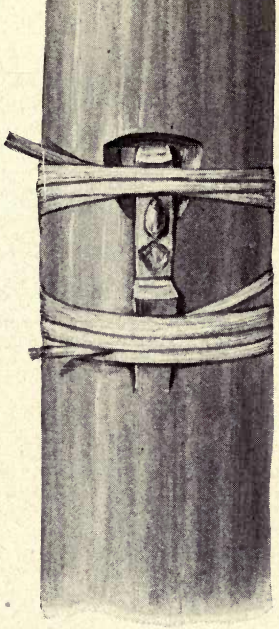


FIGURE 26

Chip bud in place in bark slot, ready for paraffin coating.

FIGURE 27
Bud inserted in ordinary T cut.

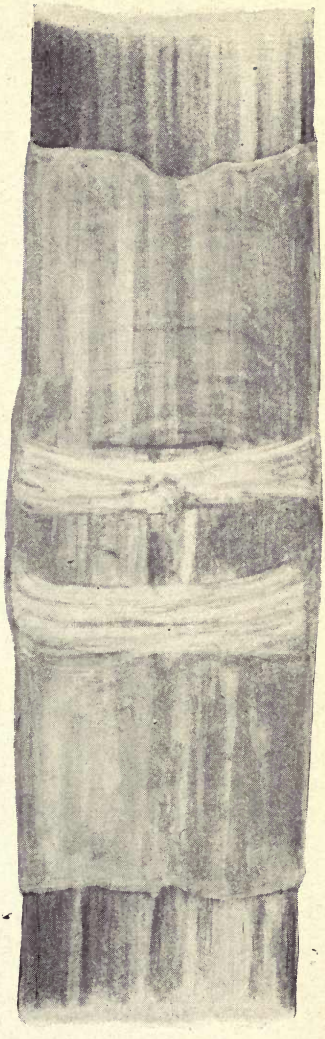


FIGURE 28
Paraffined bud in ordinary T cut.

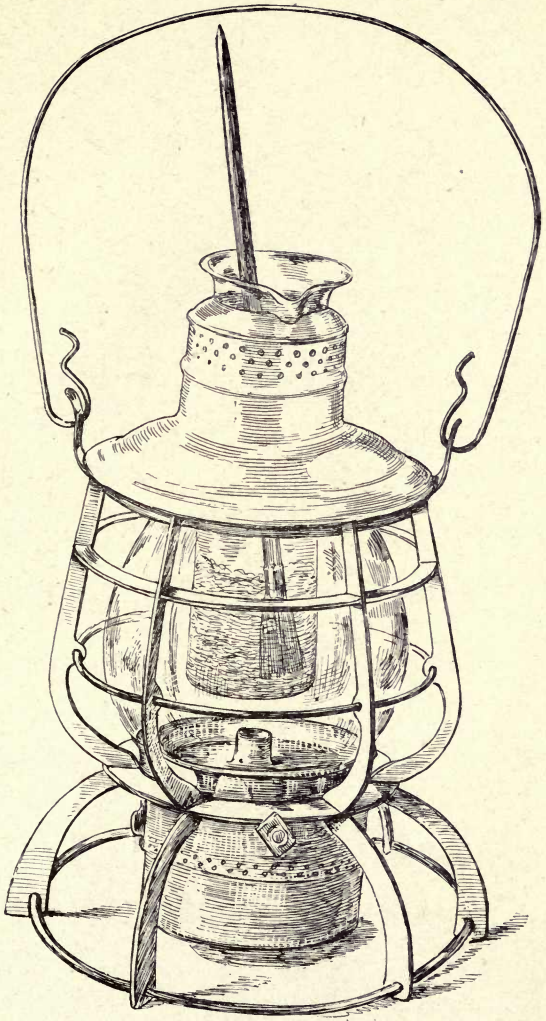


FIGURE 29
The Merribrooke Melter for Paraffin work.

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